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Hydrology of Cornfield Wash Sandoval County New Mexico, 1951–55

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1475–B

Prepared in cooperation with
the U.S. Bureau of Land Management

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By F. W. KENNON *and* H. V. PETERSON

HYDROLOGY OF THE PUBLIC DOMAIN

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HYDROLOGY OF CORNFIELD WASH, SANDOVAL COUNTY, NEW MEXICO, 1951–55

By F. W. Kennon and H. V. Peterson

ABSTRACT

This report presents detailed records of precipitation, runoff, and sediment yield for a 5-year period 1951–55 for the Cornfield Wash drainage basin located in northwestern New Mexico. Cornfield Wash is an ephemeral stream, tributary to the Rio Puerco through Arroyo Torreon and Chico Arroyo. The basin, which has an altitude ranging from 6,600 to 7,000 feet, is typical of the large semiarid area in northwestern New Mexico and northeastern Arizona.

The investigations at Cornfield Wash are part of a program involving data gathering and research for use in the design of effective and practical land-treatment methods for conservation of public domain lands under the soil and moisture program of the Department of the Interior.

Measurements of runoff and sediment yield were made in a series of 12 small stock-water reservoirs, which in 1951 ranged in capacity from 4.6 to 323.6 acre-feet. By 1955, as a result of sediment deposition, the capacities ranged from 1.9 to 174 acre-feet. Three additional reservoirs, ranging in capacity from 17.9 to 18.3 acre-feet, were constructed in 1953–54 to reduce the sediment load entering existing reservoirs by reducing the drainage area. The uncontrolled drainage area for the reservoirs ranged from 0.17 to 7.44 square miles.

Precipitation averaged 5.71 inches during the runoff season, which extends from June 1 through September 30. Annual runoff of individual reservoirs during the same period ranged from 18.0 to 56.4 acre-feet per square mile; the average for the 22.9 square miles of basin studied was 37.7. This unit runoff was compared with that measured at other gaging stations on ephemeral streams of the middle Rio Grande region during 1951–55 and was found to be the highest amount observed. Reasons for the high unit runoff in Cornfield Wash are not clear, although it is apparently due in part to greater precipitation and to the relative impermeability of the soil mantle within the basin.

The average annual accretion of sediment at the reservoirs ranged from 0.5 to 5.5 acre-feet per square mile of drainage area, the average for the basin being 2.80. The aggregate capacity of the 15 reservoirs was reduced 39 percent during the period.

For effective flood control on areas comparable to Cornfield Wash, conservation structures should be designed with a storage capacity of about 40–60 acre-feet per square mile of drainage area. The allocation for storage of sediment should be about 2.5–3.0 acre-feet per square mile of drainage area annually for the expected life of the structure.

INTRODUCTION

LOCATION AND GENERAL FEATURES

The Cornfield Wash basin has an area of 25.9 square miles and lies about 55 miles northwest of Albuquerque between the small settlements of Cuba and San Luis in Sandoval County, N. Mex. (see fig. 10). Cornfield Wash is tributary to Arroyo Torreon, which flows into the Rio Puerco through Chico Arroyo, as shown in figure 11. It is representative of the upper Rio Puerco basin, an area well known for excessive erosion and high sediment yield.

Land within and extending for many miles beyond the limits of the Cornfield Wash basin is used mainly for livestock grazing, except for a very minor acreage used for flood-irrigation farming by Navajo Indians. About 150 Indians live within the area, with families occupying individual hogans scattered throughout the basin. Most of the families own small herds of sheep, which are usually grazed

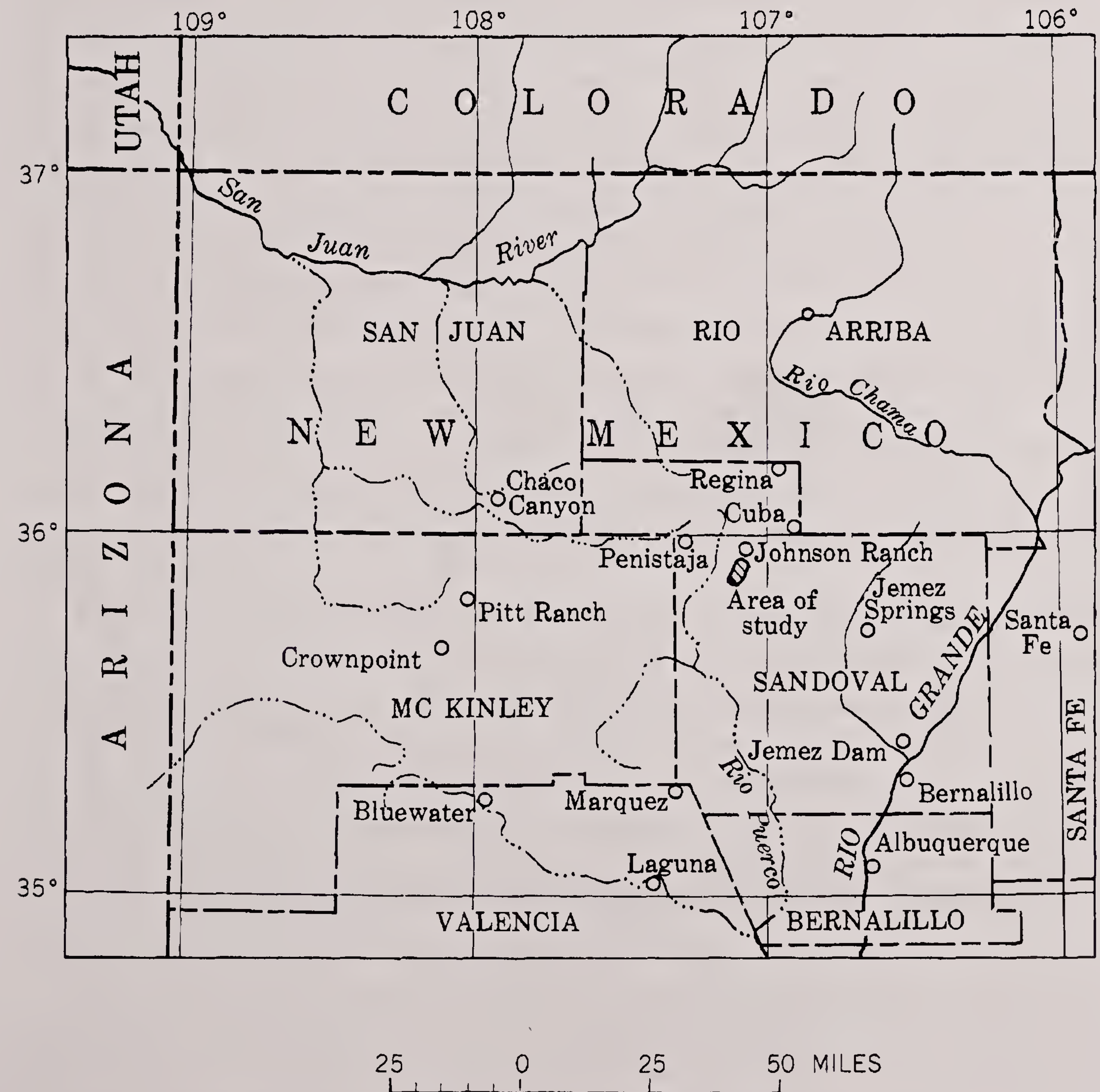

FIGURE 10.—Index map showing location of Cornfield Wash, N. Mex.

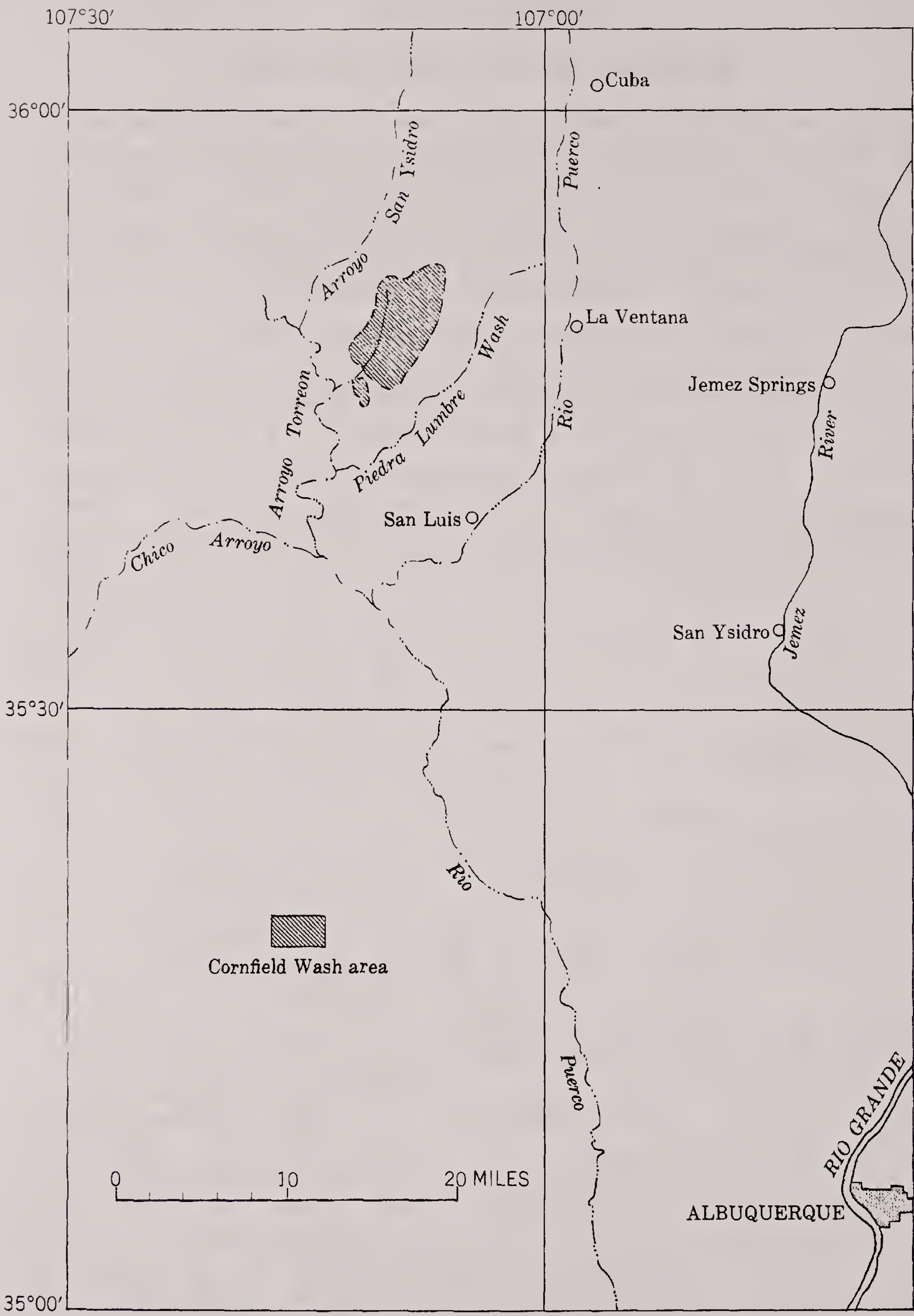

Figure 11.—Map showing relation of Cornfield Wash to nearby streams.

separately but are sometimes combined in herds of 300 or more. Federal land within the basin is administered by the Bureau of Land Management, Districts 1 and 7, New Mexico. Cattle are grazed in District 1, in the extreme eastern part of the area, on land which is allotted to non-Indians by the Bureau of Land Management.

PURPOSE AND SCOPE OF THIS INVESTIGATION

The investigations of the Cornfield Wash area are part of a program for collection of data and for hydrologic research for use in the design of effective and practical land-treatment methods for conservation of the public domain. Data on the actual rates of runoff, erosion, and sedimentation are needed for design of conservation structures. The Cornfield Wash area is one of several localities where such studies are being made under the soil and moisture conservation operation program of the Geological Survey.

The studies were started in 1950 when the U.S. Bureau of Land Management began construction of conservation structures in Cornfield Wash as part of a land-treatment program designed to reduce floodflows, alleviate erosion, stop headcutting of gullies, protect Indian farmlands in the lower part of the basin, and provide a source of domestic and irrigation water for the Indians. The program included construction of a series of retarding reservoirs located on the main channel and on some of its major tributaries. Plate 7 is a map of the area showing the location of the dams. The plan was to provide sufficient storage in each of the reservoirs to retard flood runoff from drainage areas. By using open-pipe outlets through the dams, stored floodwater could be released at rates that would cause the least erosion in the channels below. Additional outlet pipes in reservoirs 11 and 12 were provided with valves so that a small part of the stored water could be reserved for irrigation and domestic use by the Indians.

At the time the investigation was started, virtually no information was available on the magnitude of runoff or the sediment yield from drainage basins of the character and size of Cornfield Wash. Accordingly, the storage requirements for regulation of the runoff and for prospective sediment deposition in the reservoirs proposed had to be estimated. Measurements, started in 1951, were planned to continue for not less than 5 years and preferably 10 years or longer. This report summarizes data of precipitation, runoff, and sediment yield obtained in the 5-year period, 1951–55.

The studies were made under the general supervision of R. W. Davenport, chief, Technical Coordination Branch, U.S. Geological Survey. H. V. Peterson was in direct charge of the work; field operations were carried out by F. W. Kennon and assistants.

PREVIOUS INVESTIGATIONS

Reconnaissance studies of the geology of Cornfield Wash and surrounding areas were made as early as 1908, when the general locality was examined for coal. Gardner (1910) at that time made a reconnaissance map showing the area extending east and north from San Mateo to Cuba, N. Mex. Cornfield Wash is shown as being underlain by the Mesaverde formation and Lewis shale, but as the basin contains no commercial coal veins, no further details concerning the character of the rocks were reported. Later, Darton (1921) examined the general area in a reconnaissance of structures favorable for oil and gas accumulation. He mentions only the low dip of the rocks in the vicinity of Cornfield Wash.

A geologic map of the area by Dane (1936), who designated Cornfield Wash as Medio Arroyo, shows that most of the basin is underlain by the Lewis shale of Late Cretaceous age. A small area along the northwest edge is underlain by the Pictured Cliffs sandstone, and a narrow belt in the southernmost part of the basin is occupied by outcrops of the undifferentiated Allison and Gibson coal members of the Mesaverde formation. The Lewis shale in this locality is described as gray calcareous sandy shale containing buff sandstone beds 1–5 feet thick. The Pictured Cliffs sandstone is described as crossbedded buff sandstone, and the undifferentiated Allison and Gibson coal members are described as a series of alternating sandstone and shale beds with a few thin noncommercial beds of coal, some of which have burned.

These earlier reports do not mention general erosion conditions in the area or the extensive network of gullied channels which are now prominent features. Perhaps this network had not yet formed but it seems more logical to assume that geologists at the time limited their investigations to the mineral resources of the area. Except for the generalized geologic mapping, the area has received scant attention from other investigators until recently when consideration was given to problems relating to conservation and protection of the range resources.

ACKNOWLEDGMENTS

The cooperation of personnel of the Bureau of Land Management in assisting with observations, in maintaining the structures, and otherwise facilitating the study is hereby acknowledged. The enthusiastic support and interest in the study by E. R. Smith, State supervisor; Donald I. Bailey, range and forestry officer; and Harry W. Pearson, State range conservationist, all of the Bureau of Land Management, Santa Fe, N. Mex., were particularly valuable. Con-

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structive suggestions and comments on conducting the program were received from many persons in other agencies who visited and inspected the area during the study.

CLIMATE

The climate of the area including Cornfield Wash is semiarid. Table 1, compiled from records obtained at U.S. Weather Bureau stations in nearby areas (see fig. 10), shows that the average annual rainfall is about 10 inches. This table also shows precipitation during the warm (May through October) and cold (November through April) seasons. As the stations at Johnson Ranch and Penistaja are located only a few miles north of Cornfield Wash, they probably reflect more closely the precipitation on the basin than do the other stations. Records at these two stations show that about 60 percent of the annual precipitation falls in the 6-month warm period.

TABLE 1.—*Annual and seasonal precipitation and temperature in vicinity of Cornfield Wash*

Station	Elevation (feet)	Years of record	Average precipitation (inches)			Temperature (° F)		
			Annual	May to October	November to April	Mean annual	Highest	Lowest
Albuquerque	5,310	84	8.70	6.09	2.61	[1] 56.6	104	−5
Bernalillo	5,060	21	8.66	5.77	2.89	[2] 54.2	109	−18
Bluewater	6,650	39	10.10	7.45	2.65	47.7	105	−29
Chaco Canyon	6,125	15	8.53	5.42	3.11	50.7	106	−24
Crownpoint	6,978	32	10.79	7.52	3.27	[3] 50.4	97	−17
Cuba	6,945	14	14.98	8.99	5.99	46.0	102	−40
Jemez Springs	6,100	42	18.12	12.25	5.87	51.1	98	−13
Johnson Ranch	7,200	12	10.65	6.79	3.86	--------	--------	--------
Laguna	5,815	31	10.61	7.38	3.23	[4] 53.4	103	−20
Marquez	7,800	16	11.39	8.07	3.32	--------	--------	--------
Penistaja	6,950	12	8.98	5.69	3.29	--------	--------	--------
Pitt Ranch	6,000	15	8.73	6.27	2.46	--------	--------	--------
Regina	7,450	31	16.67	10.33	6.34	45.0	106	−30

[1] 53-year record. [2] 17-year record. [3] 36-year record. [4] 23-year record.

The precipitation occurs mainly as rain, although snow falls frequently in winter. Winter rains are gentle and seldom, if ever, produce runoff. Infrequently, small amounts of runoff result from melting snow. Summer precipitation characteristically occurs during cloudburst storms of high intensity, erratic distribution, and small areal extent. Such storms, which may occur from about 1 to 5 times each summer, produce the major part of the annual runoff in July and August, but occasionally some occur in June and early September.

Although the altitude of the basin exceeds 6,000 feet, the growing season is long enough so that, with floodwater irrigation, the Indian farmers grow crops of squash, corn, and barley. When moisture conditions are favorable, range grasses grow well.

PHYSIOGRAPHY

Cornfield Wash is located in the Navajo section of the Colorado Plateaus physiographic province as described by Fenneman (1931). In common with other parts of the Colorado Plateaus province, the Cornfield Wash area is characterized by horizontal or slightly inclined rock strata, relatively high altitudes, low precipitation, and scant vegetation. The area, however, does not have the deep canyons that are common in other parts of the province. The terrain within and surrounding Cornfield Wash is in effect a plateau intricately dissected by streams that have eroded moderately steep sided, shallow valleys and swales. Maximum relief between the divides and the stream channels ranges from 300 to 500 feet. The divides are narrow, elongated mesas capped by resistant thin sandstone beds, which, in places, have the appearance of red sinter or scoria as a result of the natural burning of underlying coal seams, whereas the valleys are shallow troughs cut in the softer, less resistant underlying shale.

The altitude of the basin as determined by aneroid barometer ranges from 6,600 feet on the low end of the valley floor to about 7,000 feet on the drainage divides. Slopes of valley sides range from 1 to 2 percent along the lower parts to about 20 percent near the summits of the divide. The main-channel gradients are about 1 percent or more in the lower part of the basin and become progressively steeper towards the upper part.

Cornfield Wash has two principal tributaries, designated as the East and West Forks, which join just below reservoirs 11 and 12. (See pl. 7). The divide between the two tributaries as well as the divides between the basin and adjacent basins are flat or slightly rounded. The slopes below the divides are dissected by a network of shallow tributary washes that drain directly downslope to the main channels. Debris washed from the valley slopes is deposited along the valley bottoms, forming a floor of alluvium about 10–30 feet thick, and alluvium of varying thickness floors the smaller tributaries.

Both main tributaries have gullied their valley floors for most of their entire length. The gullies range from 20 to 50 feet in width and from 5 to 25 feet in depth (see pl. 8A). Generally the depth of a gully is limited by the presence of sandstone or resistant shale in the channel bottom (see pl. 8B). Many of the tributary washes, which dissect the valley slopes, have cut gullies in their lower reaches. These join the gullied parent stream at grade, with the result that the confluence of the streams may be as much as 20 feet below the level of the valley floor. Under these conditions, sediment is not deposited en route but is transported directly to downstream reservoirs. Tribu-

taries which have not cut gullies in their lower reaches are graded to the valley floor, and most of the sediment carried by floodflows is deposited on the valley floor as alluvial fans, unless the flows are large enough to extend across the fans and spill into the main channel.

GEOLOGY AND SOIL

The geology of the area is relatively simple. The Lewis shale, which underlies most of the area, is uniform thin-bedded moderately indurated marine shale containing scattered thin lenticular beds of sandstone. The shale forms slopes of uniform gradient, and the sandstone layers generally cap elongated mesas or ridges of varying size. The undifferentiated Allison and Gibson coal members of the Mesaverde formation (Dane, 1936) contain a greater proportion of sandstone, and consequently the slopes on these members are somewhat steeper than in other parts of the basin.

Soil on the slopes of shale consists of a thin mantle of disintegrated bedrock, largely devoid of organic matter. There is little evidence of a soil profile, and the soil generally grades from a mixture of clay and silt at the surface to the parent rock at a depth of 2–3 feet. The clay is bentonitic and usually exhibits distinct swelling and dispersion when wetted, resulting in low infiltration rates and rapid runoff. In contrast, the sandstone mesas have sandy soil with a high infiltration rate. The general sparsity of drainage channels on these surfaces indicates that the mesas have low overland flow.

The valleys along the two principal stream channels and their larger tributaries are underlain by alluvial deposits as much as 30 feet thick. The alluvium reflects the lithologic character of the bedrock from which it originated and consists mainly of silt and clay with scattered lenses and stringers of sandy material. These alluvial valley floors formerly produced the best forage in the area, presumably largely owing to the additional water they received by overflow from the channels prior to gullying. After the channels were gullied, the valley floors no longer received flood overflow and, in consequence, their present (1955) productivity is no greater than that of other parts of the basin.

VEGETATION

Vegetation in the basin is generally sparse. It consists of scattered clumps of grass, mainly galleta (*Hilaria Jamesii*) and blue grama (*Bouteloua gracilis*), intermingled with sagebrush (*Artemisia tridentata*) and scattered stunted trees of juniper (*Juniperis monosperma*) and piñon (*Pinus edulis*). Trees and shrubs generally pre-

A, GULLIED CHANNEL, EAST FORK CORNFIELD WASH, BELOW RESERVOIR 5

B, CHANNEL OF EAST FORK ABOVE RESERVOIR 12
Depth is controlled by sandstone layer.

A, TYPICAL VEGETATION IN CORNFIELD WASH, RESERVOIR 5 DRAINAGE BASIN

B, RESERVOIR 6 ON EAST FORK CORNFIELD WASH IN 1951

Rectangular borrow pit partly filled with water is located directly above dam.

A, GULLIED CHANNEL ABOVE RESERVOIR 13

B, INDIAN LIVESTOCK WATERING AT RESERVOIR 1, CORNFIELD WASH

AGGRADATION ABOVE RESERVOIR 7, INDUCED BY A HOG-WIRE BARRIER

This reach of the channel was formerly gullied to a depth of 12 feet.

dominate in areas of more sandy soil, such as on ridgetops and slopes that are underlain by sandstone, whereas the grasses grow on the shaly slopes and areas with heavy clay or silty soil (see pl. 9A). A considerable area in the lower part of the basin is devoid of vegetation except for scattered piñon and juniper trees. Although barren, these areas generally are not extensively rilled or dissected; they are characterized by a smooth slightly undulating surface typical of clay "slicks" commonly found on heavy soils in arid regions where the vegetation has been completely removed.

Sheep and cattle graze in all parts of the basin. In the lower part there was little change in the amount of vegetation during the 5-year period, 1951–55; but along the divide between the East and West Forks and in the upper parts of the small tributary basins on the East Fork, vegetation increased noticeably.

STUDY PROCEDURES

Details of the reservoirs constructed in the Cornfield Wash basin are given in table 2 and the locations are shown on plate 7. Reservoir 8, located just below reservoir 7, was constructed to divert water to a series of spreader dikes alined along the right bank of the channel. As the storage capacity above this dam was small, it filled with sediment within a year, and no effort was made to use the reservoir for observation. Although the spreading area is small, comprising no more than about 300 acres at maximum water level, there is doubtless some loss of water from the outflow of reservoirs 6 and 7 and from other sources as it passes through the spreader system. Excess water drains back to the East Fork channel through an inclined pipe at the east end of the downstream spreader, but it was impractical to make measurements of this return flow. The spreading area is included as part of the drainage area above reservoir 12 and this basin is, therefore, controlled to a small extent by the spreaders.

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TABLE 2.—*Reservoirs in Cornfield Wash*

Reservoir	Date constructed	Uncontrolled drainage area (sq mi)	Initial capacity		Capacity in November 1955		Diameter of outlet pipe (inches)
			Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	
1	1950	0.39	24.0	61.5	13.5	34.6	8
2	1950	1.09	54.1	49.7	45.4	41.7	8
3	1950	.31	5.9	19.0	3.2	10.3	
4	1950	1.42	22.1	15.6	18.5	13.0	
5	1950	1.04	9.2	8.8	3.5	3.4	10
6	1950	[1] 3.20	44.9	14.0	7.4	2.8	[2] 6
7	1950	[3] 1.20	15.0	12.5	6.9	13.8	10
8 [4]							
9	1950	.17	4.6	27.0	3.1	18.2	
10	1950	[5] 3.19	48.6	15.2	37.2	11.6	8
11	1950	3.0	166.8	55.6	107.3	35.7	[6] 24
12	1950	[7] 7.44	323.6	43.5	174.0	23.4	[6] 24
13	1950	.45	7.4	16.4	1.9	4.2	
Total		22.90					
15	May 1953	1.10	17.9	16.3	17.9	16.3	10
16 [8]	April 1953	.70	28.9	41.3	27.6	39.5	10
17 [9]	May 1954	.56	18.3	32.7	17.6	31.3	10
Total			791.3		485.0		

[1] Reduced to 2.64 sq mi by construction of reservoir 17.
[2] Reservoir has three outlet pipes.
[3] Reduced to 0.50 sq mi by construction of reservoir 16.
[4] Diversion dam for spreading area.
[5] Reduced to 2.09 sq mi by construction of reservoir 15.
[6] The gated pipes have an 8-in. diameter.
[7] Runoff from drainage area is influenced to some degree by spreader dikes located below diversion dam 8; at maximum level the dikes spread water over an area of 0.42 sq mi.
[8] Dam breached July 9, 1954; reconstructed May 1955.
[9] Dam breached July 22, 1954; reconstructed May 1955.

The borrow pits at all reservoirs are located just above the dams. A typical reservoir with borrow pit is shown in plate 9B. The bottoms of the pits were originally several feet below the inverts of outlet pipes, and the pits thus provided holdover storage for stock water. Most of the borrow pits are now filled with sediment. Reservoirs 2, 5, 6, 7, 10, 11, 12, 15, 16, and 17 are retarding types provided with ungated outlet pipes. Reservoir 1 has a gated outlet pipe. Reservoirs 3, 4, 9, and 13 do not have pipe outlets.

The dams at each of the reservoirs are of earthfill construction. Each has an emergency spillway cut in sandstone bedrock, where possible, or in the shale or alluvium along one of the abutments. In those reservoirs with open-pipe outlets (see table 2), the pipes generally are set near the bottom of the dam and are designed to empty the reservoir within 72 hours. In reservoirs 11 and 12, the open pipes are set higher than in the other reservoirs so that some water is held over for livestock and domestic use. A gated pipe is set below the open pipe in these reservoirs.

The reservoirs were surveyed carefully shortly after their construction, and area and capacity curves were developed. Surveys

also were made yearly at the end of each runoff season. The reduction in capacity was considered to be a measure of the accretion of sediment during the previous year. No adjustment was made for sediment which might have passed through the outlet pipes or through the spillway, as this amount is considered to be only a small percentage of the total. Also no adjustment was made for compaction of sediments in the reservoirs, as it is believed that any change in volume resulting from compaction would be so small as to be within the limit of error in surveying. Any sediment which passes through one of the upstream reservoirs is trapped in downstream reservoirs, and the only sediment loss in the system would be the small amount which escaped through the outlet pipes of reservoirs 11 and 12 or when reservoir 12 spilled on two occasions.

Runoff was measured in each of the reservoirs by taking weekly or more frequent readings of gages, which showed the water level and maximum stage that had occurred since the last visit. A water-stage recorder was installed in reservoir 2 in 1953 and another was installed in reservoir 5 in 1955. Crest-stage gages were installed at all other reservoirs. These gages were read weekly to obtain stage data for high water that occurred between visits. Stage graphs were constructed from these data, as shown on figure 12. The change in

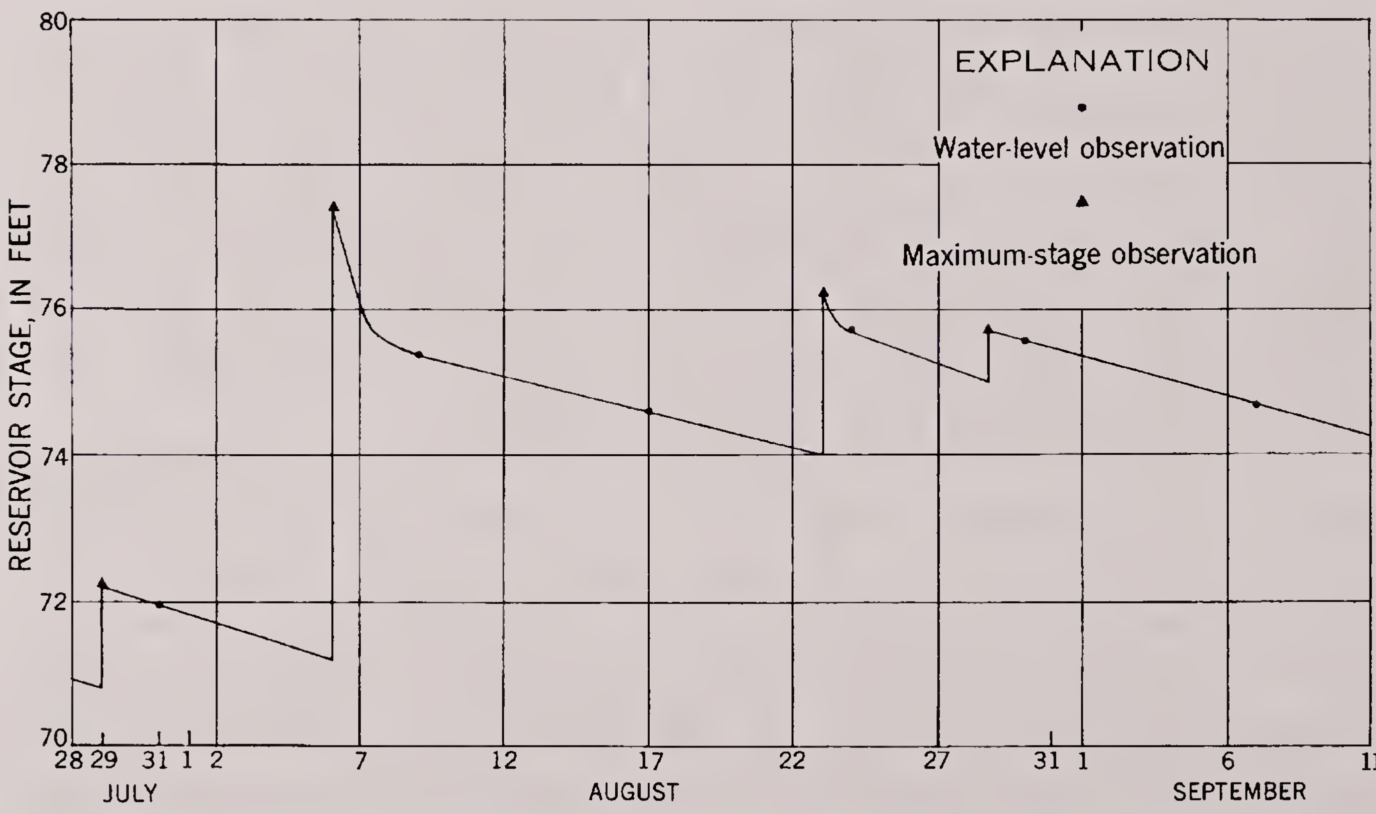

FIGURE 12.—Water-stage graph for the period July 28 to September 11, 1955, reservoir 9, Cornfield Wash.

stage during inflow was inferred from such graphs and converted to volumes of runoff through use of the stage-capacity curves for each reservoir. Adjustments for changes in capacities resulting from deposition of sediment were made on the basis of the annual reservoir

surveys. Measurements of runoff were made only during the warm period (May through October), because runoff is practically negligible during the remainder of the year.

The storage capacity of several of the reservoirs was insufficient to contain all the runoff and, therefore, spill occurred. However, the aggregate capacity of the reservoirs was sufficient to store all runoff from the basin, except on two occasions when storms caused spill from the lowest reservoir—72.0 and 71.0 acre-feet from reservoir 12 on July 22, 1954, and August 4–7, 1955. Thus, a measurement of the total runoff from the basin is available. Spill from individual reservoirs was determined indirectly by the method described in the section "Runoff."

PRECIPITATION AND RUNOFF

PRECIPITATION

Precipitation data were considered of secondary importance at the beginning of the study because the primary objective was to obtain data on runoff and sediment yield, thus, few precipitation records were obtained during the early phase. Later, as it became evident that summer rainfall over an area of even 23 square miles could be extremely erratic and spotty and would, therefore, have a significant influence on runoff and sediment yield, efforts were made to increase the number of precipitation gages.

An improvised type of long-term recording rain gage was installed near reservoir 6 in July 1951. However, owing to mechanical difficulties, a record was obtained only for parts of the seasons in 1952 and 1955, and no record was obtained in 1953. In 1953 a tipping-bucket gage was attached to the water-stage recorder on reservoir 2, but it also failed to operate properly at times. No other recording gage was available for use during this period; therefore, to augment the recorder records, bucket gages (5-quart oilcans) were set out at various points in the basin. Oil was used to retard evaporation from these gages. The location of the bucket gages is shown on plate 7. The catch in these gages was measured at about weekly intervals. When more than one storm occurred between measurements, the catch for each storm was determined on the basis of records from the recording gages. Although the cans were frequently tipped over by livestock or destroyed by vandals, fairly complete records were obtained. Gages located near reservoirs were assigned the same number as the reservoir. Gages 1 and 12 were located at greater distances from their respective reservoirs than were other gages in order to improve coverage.

Records of seasonal precipitation and of individual storms are presented in table 3. The amounts given represent the average catch in all gages within the basin and the extremes of highest and lowest precipitation for individual storms at different gages. Data on storm precipitation obtained from recording precipitation gage 6, located between reservoirs 6 and 7, are given in table 4. Rainfall for the more intense storms is given.

Tables 3 and 4 indicate that there was at least one major storm during each summer. On July 31, 1951, 1.06 inches fell in 30 minutes; July 21, 1954, 0.89 inch fell in 30 minutes; and on August 6, 1955, 1.05 inches fell in 18 minutes. No detailed records of the major storms of 1952 and 1953 are available, but runoff records and observations at nonrecording rain gages indicate that the storms of August 12, 1952, and July 17, 1953, were probably about equal in magnitude to those described above.

In 1950 the U.S. Soil Conservation Service studied all available recording rain-gage records for the Southwest. The frequency of storms of various magnitudes and durations was determined. The study shows that at Cornfield Wash a storm yielding about 1 inch of rainfall in 30 minutes might be expected on the average of once every 50 years. As previously mentioned, two or more such storms occurred during the 5-year period of observation.

Another characteristic of the storms in this area is the marked variation in total amount of rainfall from place to place. This variation cannot be shown for single storms because only one recording rain gage was available, but the network of nonrecording gages observed weekly makes it possible to show the variations in weekly precipitation. Figures 13–15 show typical precipitation patterns of the area. Such areal variation in rainfall would, of course, largely account for the marked differences in unit runoff so frequently observed.

The seasonal runoff in Cornfield Wash measured during the 5-year period was much higher than was expected, which led some observers to believe that summer rainfall was greater here than at other nearby areas. A comparison was made between the precipitation at Cornfield Wash and 10 other stations in northwestern New Mexico for identical periods of time. The results are shown in table 5, which shows that Cornfield Wash received more summer precipitation during the 5-year period, 1951–55, than did six other stations in the vicinity, but they do not clearly indicate whether precipitation for the period was above or below normal. In general, it might be concluded that precipitation at Cornfield Wash was less than normal, as the average at all 10 U.S. Weather Bureau gages was less than the long-term averages by as much as 15 percent.

TABLE 3.—*Precipitation in Cornfield Wash basin for the warm seasons, May through October, 1951–55*

Period of record	Gages in operation	Average of all gages (inches)	Minimum		Maximum	
			Inches	Gage	Inches	Gage
1951						
July 18–Sept. 12	6, 10	3.91				
1952						
Mar. 6–Sept. 30	6	7.05				
1953						
May 1–June 18	6, 10	0				
June 19–July 14	2	.2				
July 15	2	.2				
July 16–17	2	2.50				
July 26–31	1–6, 11	1.57	0.5	1	1.8	3
Aug. 11	1, 2, 4, 6	.32	0	1	.6	4
Aug. 12–Sept. 3		0				
Total		4.79				
1954						
Mar. 21–24	1, 4, 5, 6, 10	1.0	.50	1	1.9	4
May 10	1, 6	.22	.20	1	.25	6
June 4–July 8	1, 6, 13	1.1	.8	1	1.4	13
July 9	6	.86				
July 16	6	.08				
July 17	6	.13				
July 21–23	1–6, 10, 11, 12, 13, 15	2.14	.92	5	2.94	10
July 31	1, 2, 6, 10, 11, 12, 15	.16	0	6	.36	15
Aug. 10	1, 6	.28	.25	6	.30	1
Aug. 15–17	1, 3, 4, 5, 6, 13	.53	.26	6	.74	13
Aug. 25–Sept. 2	1, 3, 4, 5, 6, 10, 11, 12, 13	.24	0	6	.48	10
Sept. 3–25	1, 3, 4, 5, 6, 10, 11, 15	2.26	1.98	15	3.00	13
Sept. 26–30	1, 3, 4, 5, 6, 10, 11, 15	0	0		0	
Total		9.00				
1955						
May 1–July 1	5, 6	1.0	1.0	5	1.0	6
July 2–20	2, 5, 6	.39	.36	2	.44	6
July 21–30	1, 2, 3, 4, 5, 6, 10, 11, 13, 15	2.03	1.15	6	3.48	1
Aug. 4–10	2, 3, 4, 5, 6, 10, 11, 12, 13, 15	2.04	1.35	11	2.74	2
Aug. 13–16	1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15	.55	0	1	1.26	12
Aug. 17	1, 2. 3, 4, 5, 6, 10, 11, 12, 13, 15	.02	0	6	1.3	2
Aug. 18–24	1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15	.86	.2	1	1.5	11
Aug. 25–30	1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15	.36	.1	1	.6	15
Aug. 31–Sept. 7	1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 15	.05	0	6	.15	4
Sept. 8–30	3, 5, 6	.17	.05	6	.25	3
Total		7.47				

TABLE 4.—*Storm precipitation measured at recording gage 6*

Date	Total precipitation (inches)	Period (hours)	Maximum intensity	
			Rate (in. per hr)	Period (min)
1951				
July 24	0. 08	0. 2		
30	. 07	. 5		
31	1. 55	10. 5	1. 87	36
Aug. 2	. 10	. 2		
4	. 28	. 2		
18	. 02	. 1		
21	. 48	3. 7		
24	. 29	2. 0		
28	. 19	2. 4		
29	. 10	. 2		
1952				
Apr. 19	. 65	5. 3		
22	. 10	. 7		
27	. 59	10. 6		
28	. 11	6. 0		
June 10	. 10	4. 5		
26	. 16	4. 5		
27	. 74	13. 0		
28	. 05	4. 0		
July 1–19	1. 80	(1)		
22–Aug. 4	. 80	(1)		
Aug. 6–28	1. 00	(1)		
25	. 65	2. 5	2. 10	6
26	. 22	. 3		
28	. 08	1. 3		
1953 [2]				
1954				
May 10	. 25	20. 0		
July 9	. 86	1. 1	1. 64	22
16	. 08	. 05		
17	. 13	. 5		
21	1. 00	1. 5	1. 78	30
22	. 80	6. 0		
23	. 34	6. 0		
Aug. 10	. 25	16. 0		
15	. 11	6		
17	. 15	6	. 20	30
Sept. 3	. 15	2		
12	. 78	5	. 80	30
22	. 15	2		
24	. 65	6. 5		
25	. 40	. 7	3. 5	6

[1] Gage inoperative.
[2] Gage not operated as a recorder during this season.

TABLE 4.—*Storm precipitation measured at recording gage 6*—Continued

Date	Total precipitation (inches)	Period (hours)	Maximum intensity	
			Rate (in. per hr)	Period (min)
1955				
July 11	0.44	0.1		
21	.03	.1		
22	.08	.1		
25	.19	3.5		
26	.13	3.0	0.80	6
27	.55	7.5	1.50	12
29	.09	3.5	.60	6
30	.08	.5		
Aug. 4	.40	.2		
6	1.19	4.9	3.5	18
7	.33	2.0		
8	.02	.1		
10	.17	2.0		
11–16	.15	(1)		
18	.03	.5		
20	.08	.5		
21	.21	.7	.90	12
23	.08	.8		
27	.11	1.1		
Sept. 17	.05	2.1		

1 Gage inoperative.

TABLE 5.—*Comparison of average precipitation, June through September 1951–55, and long-term average, June through September, at U.S. Weather Bureau stations in the vicinity of Cornfield Wash*

Station	Altitude (feet)	Years of record	Average (inches)	
			1951–55	Long-term
Albuquerque	5, 310	84	3. 85	5. 22
Bernalillo	5, 060	21	4. 18	5. 14
Chaco Canyon	6, 125	15	3. 23	4. 70
Cuba	6, 945	14	6. 04	8. 01
Jemez Springs	6, 100	42	7. 86	10. 85
Laguna	5, 815	31	4. 07	6. 74
Regina	7, 450	31	6. 19	9. 17
Johnson Ranch	7, 200	12	4. 90	6. 03
Pitt Ranch	6, 000	15	4. 65	5. 58
Marquez	7, 800	16	6. 54	7. 37
Cornfield Wash	6, 600–7, 000		5. 71	
Average of the 10 U.S. Weather Bureau stations			5. 15	6. 88

533230 O—60——4

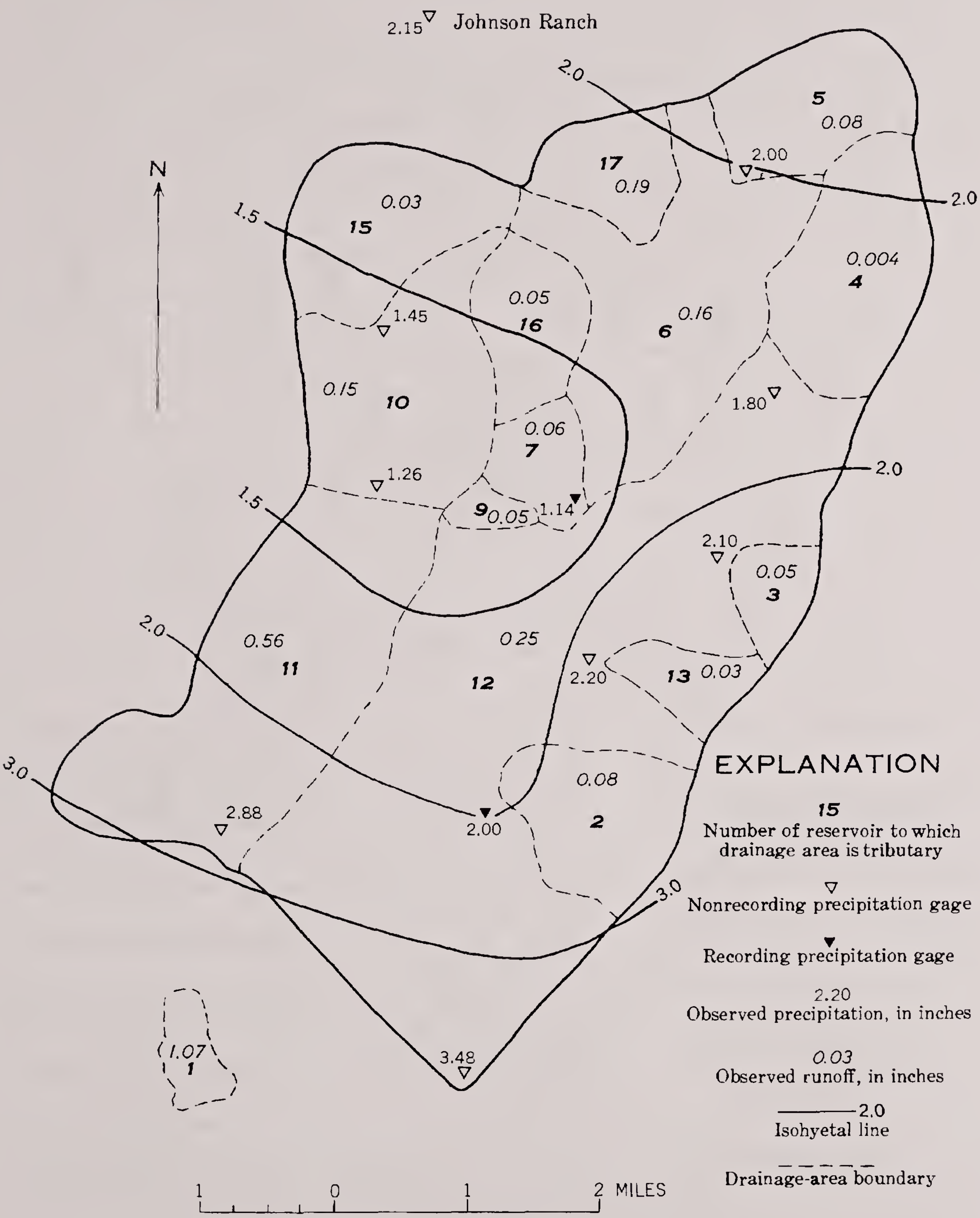

FIGURE 13.—Rainfall and runoff, July 21–30, 1955.

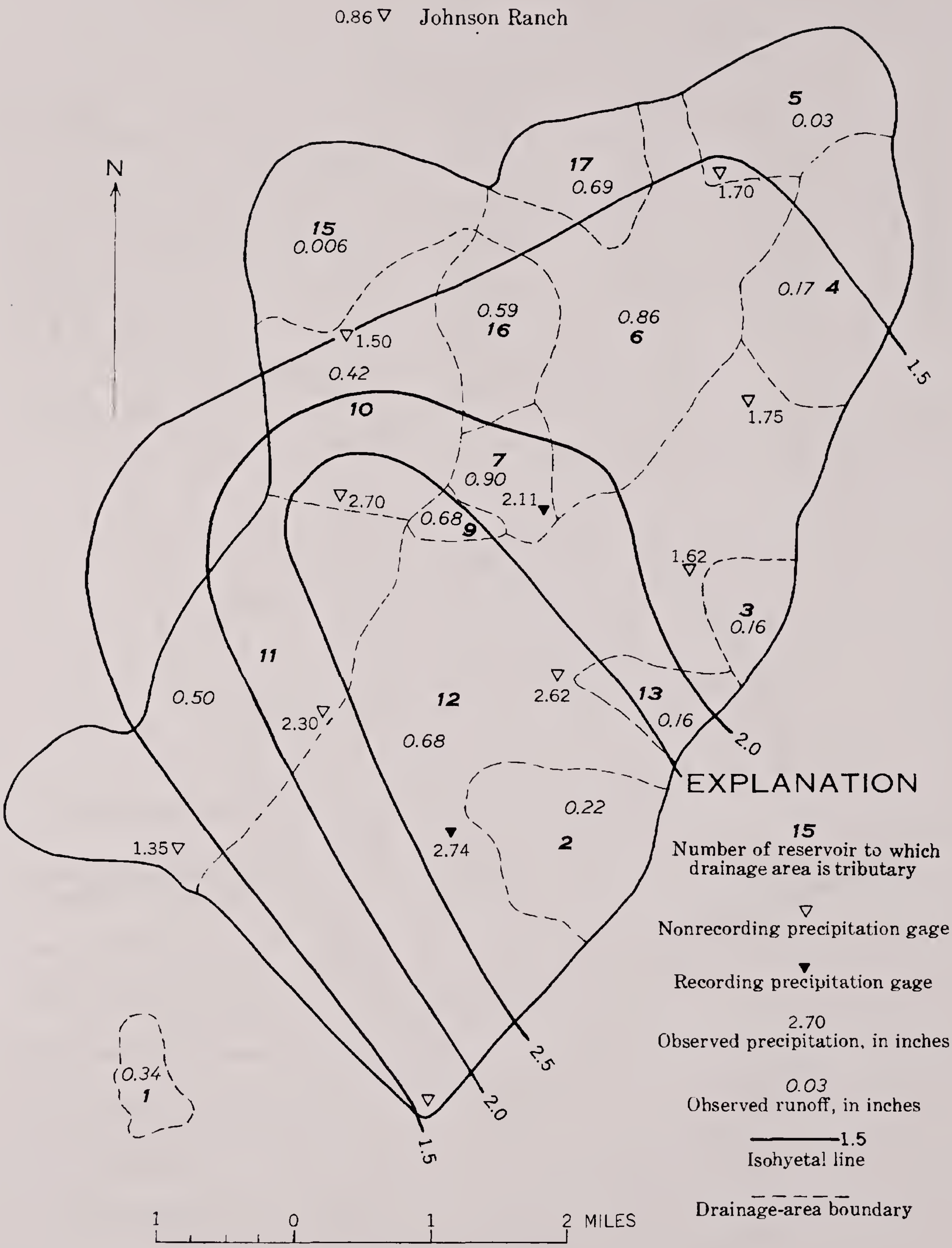

FIGURE 14.—Rainfall and runoff, August 4–10, 1955.

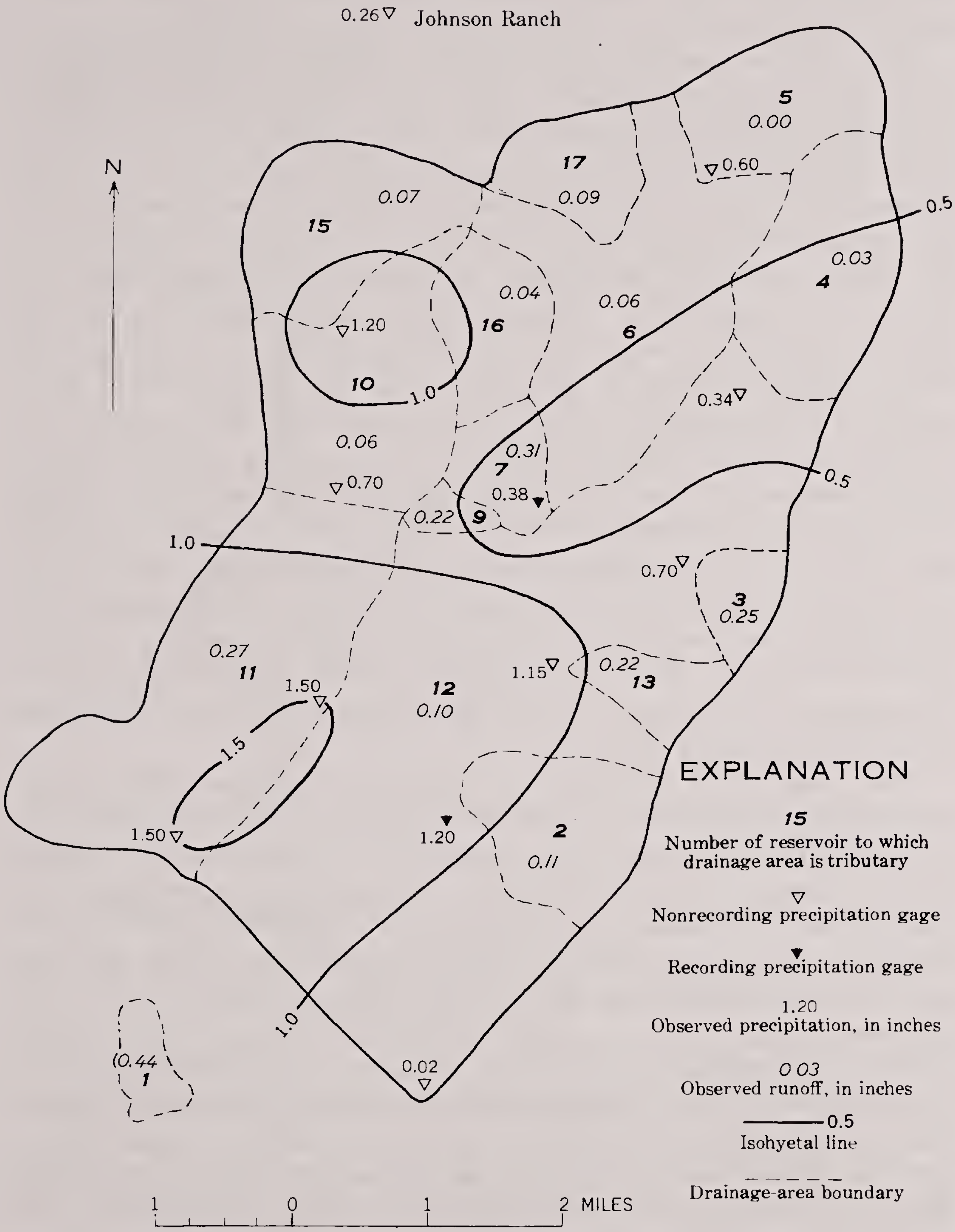

FIGURE 15.—Rainfall and runoff, August 18–24, 1955.

RUNOFF

Most runoff observed at Cornfield Wash resulted from thunder showers during June through September; occasionally a little runoff occurred in October. The typically short but intense storms generate streamflow which normally lasts for only a few hours.

The average summer runoff for the nearly 23 square miles of drainage area studied during the 5-year period is 863 acre-feet, about 37.7 acre-feet per square mile. This appears to be an abnormally high rate of unit runoff compared with other parts of the Rio Puerco basin and other drainage basins of the Southwest having similar characteristics. Records of flow for other ephemeral streams of the Southwest are rather meager, especially for drainage basins of less than 100 square miles. The records that are available for the Rio Puerco and nearby streams are summarized in table 6. Average values of runoff in acre-feet per square mile for June through September for the period 1951–55 are compared with the average unit runoff observed at Cornfield Wash. Of 21 gaging stations listed, 12 are operated by the Geological Survey and the remainder by the U.S. Agricultural Research Service. The latter includes 3 stations near Santa Fe, 2 near Albuquerque, and 4 near Safford, Ariz. The stations near Safford and the station on San Simon Creek in Arizona are included because the precipitation patterns are similar to those in the Rio Puerco. Location of gaging stations is shown on figure 16 together with average values of seasonal unit runoff occurring above or between stations.

Unit runoff at Cornfield Wash was higher than that observed at any of the other stations. Only at stations 3, 10, and 11 was unit runoff more than one-half the value of 37.7 acrea-feet per square mile per season at Cornfield Wash. As mentioned previously, the June through September precipitation at Cornfield Wash for 1951–55 was 15 percent higher than the average observed at nearby stations, and this may account for part of the excessive runoff. It is also apparent, especially from records for the Rio Puerco, that channel losses may progressively reduce unit runoff as the drainage basin increases in size. For example, the unit runoff for the Rio Puerco above the mouth of Chico Arroyo is 15.4 acre-feet per square mile; and for Chico Arroyo above its mouth, which includes Cornfield Wash, it is 17.6 acre-feet per square mile. Further downstream on the Rio Puerco the runoff at the gaging station at Rio Puerco is reduced to 9.1 acre-feet per square mile, and at the gaging station near Bernardo still further downstream runoff is only 8.0 acre-feet per square mile. Thus in the reach of the channel between Rio Puerco and Bernardo losses exceed inflow so that there is a net loss

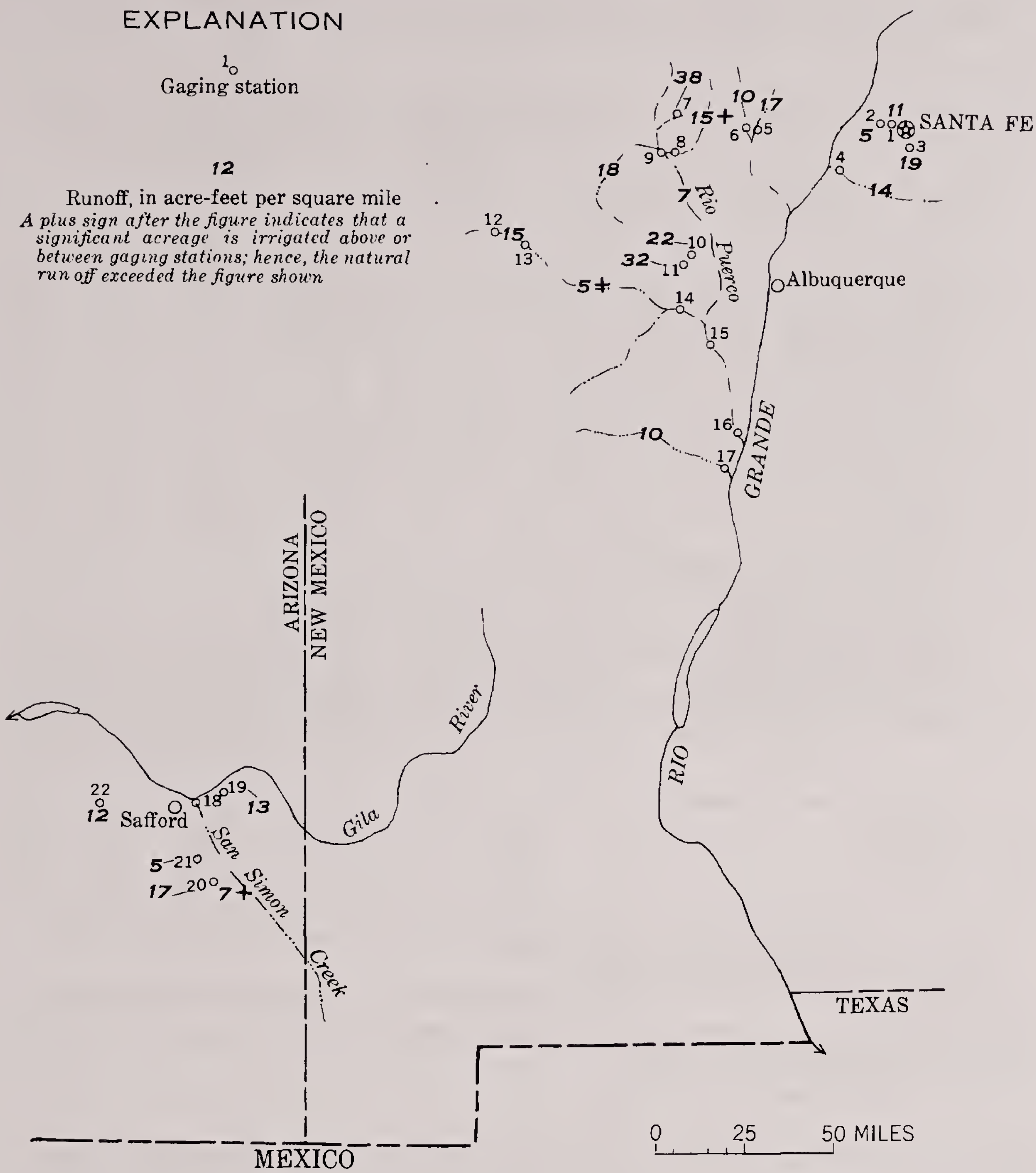

FIGURE 16.—Map showing average runoff for June to September, in acre-feet per square mile, for the period 1951–55 at indicated gaging stations.

of 0.4 acre-feet per square mile. In this reach of the channel, there are no diversions to which these losses could be attributed.

Although the difference in unit runoff between Cornfield Wash and the larger drainage basins might be attributed to higher channel losses in the latter, it fails to explain why runoff of Cornfield Wash is so much greater than that observed on most of the small Agricultural Research Service watersheds. Table 6 shows the ratio of runoff, in inches, to precipitation, in inches, for watersheds studied by the Agricultural Research Service and for Cornfield Wash. Only at watershed Albuquerque W3 was the Cornfield Wash ratio of 0.13 exceeded. The average ratio for the 7 watersheds near Santa Fe and

TABLE 6.—*Comparison between unit runoff measured at gaging stations on ephemeral streams in western New Mexico and southeastern Arizona (1951–55 averages)*

No. on fig. 16	Gaging station or area	Drainage area (sq mi)	Area irrigated above station (acres)	Period of measurement	June–Sept. precipitation (inches)	Ratio of runoff to precipitation	Runoff (acre-ft per sq mi)
	New Mexico						
1	Santa Fe W1 [1] [2]	0.22	0	June–Sept	5.61	0.04	11.2
2	Santa Fe W2 [1] [2]	1.23	0	do	4.00	.02	5.3
3	Santa Fe W3 [1] [2]	.08	0	do	6.16	.06	19.2
4	Galisteo Creek at Domingo [3]	640	50	Water year [4]			14.3
5	Jemez River below East Fork near Jemez Springs.[3]	194	0	June–Sept			17.1
6	Rio Guadalupe at Box Canyon near Jemez.[3]	226	0	do			9.8
7	Cornfield Wash	22.5	0	do	5.71	.13	37.7
8	Rio Puerco above Chico Arroyo near Guadalupe.[3]	420	3,700	Water year [4]			15.4
9	Chico Arroyo near Guadalupe [3]	1,390	100	do.[4]			17.6
10	Albuquerque W1 [2]	.15	0	June–Sept	3.37	.12	21.7
11	Albuquerque W3 [2]	.29	0	do	3.44	.18	31.6
12	Bluewater Creek below Bluewater Dam.[3] [5]	215	0				
13	Bluewater Creek near Bluewater [3] [5]	235	0				
	Area between stations 12 and 13.[6]	20		June–Sept			14.8
14	San Jose River at Correo [3]	2,610	[7] 8,600	Water year [4]			4.7
15	Rio Puerco at Rio Puerco [3]	5,160	12,300	do.[4]			9.1
	Area between stations 9 and 15, excluding area above station 14.[6]	740		do.[4]			6.9
16	Rio Puerco near Bernardo [3]	5,860	12,300	do.[4]			8.0
	Area between stations 15 and 16 [6]	700		do.[4]			−.4
17	Rio Salado near San Acacia [3]	1,380	100	do.[4]			9.7
	Arizona						
18	San Simon Creek near Solomon [3]	2,192	[7] 13,800	do.[4]			6.6
19	Safford W1 [2]	.81		June–Sept	3.81	.07	13.3
20	Safford W5 [2]	1.13		do	4.90	.06	16.8
21	Safford W4 [2]	1.19		do	4.40	.02	5.0
22	Safford W2 [2]	1.07		do	6.75	.03	12.4

[1] Station discontinued December 1948; seasonal precipitation and runoff figures are for period 1939–48.
[2] Data from U.S. Agricultural Research Service (1956).
[3] Data from U.S. Geological Survey (1953–57).
[4] As practically all runoff occurred from June througn September, use of water year is believed to introduce no serious error.
[5] Flow regulated by Bluewater-Toltec Reservoir (capacity 46,000 acre-feet), which is located on Bluewater Creek 9 miles west of Bluewater, N. Mex.
[6] Areas between stations are not irrigated.
[7] Most of the area is irrigated by ground water.

Safford is 0.04 or about one-third of the ratio at Cornfield Wash. Since this ratio varies inversely with the infiltration rate, it would seem that the Cornfield Wash basin as a whole has a relatively low infiltration rate and, consequently, yields a relatively large runoff.

A summary of the seasonal runoff and the annual sediment deposition measured at each of the reservoirs is given in table 7. Runoff during individual storms at each of the reservoirs during the 5-year period, 1951–55, is shown in table 8. The inflow stored is the amount of runoff temporarily impounded in the reservoir below spillway level. The spill is the amount passing over the spillway. Total inflow is the sum of these two amounts and includes any spill from an upstream reservoir. The inflow, in acre-feet per square mile, is the unit runoff from the uncontrolled drainage area only. In calculating this amount the spill from upstream reservoirs is excluded.

TABLE 7.—*Seasonal runoff and annual*

Reservoir	Drainage area[1] (sq mi)	1951				1952			
		Runoff		Sediment		Runoff		Sediment [2]	
		Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi
1	0.39	20.9	53.6	0.8	2.1	14.1	36.2	0.5	1.3
2	1.09	21.0	19.3	2.0	1.8	10.9	10.0	.1	.1
3	.31	5.3	17.1	.1	.3	8.7	28.1	.7	2.2
4	1.42	11.0	7.7	0	0	32.8	23.1	.2	.1
5	1.04	9.6	9.2	.6	.6	27.8	26.6	1.5	1.4
6	3.20	38.0	11.9	3.0	.9	112.4	35.1	2.8	.9
7	1.20	26.0	21.6	2.5	2.1	27.6	23.0	.2	.2
9	.17	4.2	24.7	.4	2.4	8.8	51.8	.1	.6
10	3.19	48.0	15.0	1.7	.5	105.8	33.2	.9	.3
11	3.00	118.0	39.3	15.0	5.0	213.3	71.1	6.5	2.2
12	7.44	271.0	36.5	22.0	3.0	[7] 275.0	36.9	13.2	1.8
13	.45	6.6	14.7	.5	1.1	9.3	20.6	.2	.4
15	1.10								
16	.70								
17	.56								
Total	22.90	579.6	25.3	48.6	2.1	846.5	37.0	26.9	1.2

[1] Drainage areas for reservoirs 1-7 and 9-13 as of May 1951, and for reservoirs 15-17 as of May 1955.
[2] Complete reservoir surveys were not made in 1952; surveys were confined to lowest part of reservoirs and, therefore, sediment deposition figures may be slightly low.
[3] Drainage area of reservoir 6 reduced from 3.20 to 2.64 sq mi by construction of dam 17, May 1954; dam breached July 1954; reconstructed May 1955.
[4] Drainage area of reservoir 7 reduced from 1.20 to 0.50 sq mi by construction of dam 16, April 1953; dam breached July 1954; reconstructed May 1955.

sediment deposition, 1951–55

1953				1954				1955			
Runoff		Sediment		Runoff		Sediment		Runoff		Sediment	
Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi	Acre-ft	Acre-ft per sq mi
15.7	40.3	4.2	10.8	20.2	51.8	1.0	2.6	39.1	100.2	4.3	11.0
29.0	26.6	4.4	4.0	23.9	21.8	.1	.1	28.2	25.9	2.4	2.2
9.1	29.3	1.0	3.2	18.2	58.8	.5	1.6	11.6	37.4	.4	1.3
24.6	17.3	2.0	1.4	42.7	30.1	1.4	1.0	17.0	12.0	0	0
6.5	6.2	1.1	1.1	52.5	50.3	.8	.8	18.4	17.7	1.2	1.2
[3] 67.7	21.3	8.7	2.7	182.2	65.4	14.0	4.4	124.9	47.2	8.7	3.3
[4] 15.4	30.8	2.0	4.0	68.8	74.9	3.5	[5] 2.9	38.7	77.4	1.2	2.4
4.4	25.9	.2	1.2	13.9	81.8	.7	4.1	9.5	55.9	.4	2.4
[6] 17.9	8.6	3.9	1.9	106.9	51.2	0	0	97.5	46.7	5.0	2.4
99.6	33.2	10.7	3.6	118.1	39.3	13.8	4.6	220.0	73.3	13.5	4.5
370.0	49.7	50.1	6.7	459.0	61.7	43.6	5.9	358.5	48.2	32.3	4.3
12.5	27.7	4.2	9.3	11.7	25.9	1.0	2.2	11.1	24.7	1.2	2.7
[8] .7	.6	0	0	6.5	5.9	0	0	2.5	2.3	0	0
[8] 9.3	13.3	--------	--------	[9] 22.8	--------	--------	--------	34.6	49.4	1.3	1.9
--------	--------	--------	--------	[9] 21.9	--------	--------	--------	28.3	50.5	.7	1.2
682.4	29.8	92.5	4.0	1166.3	50.9	80.4	3.5	1039.9	45.4	72.6	3.2

[5] Drainage area of 1.2 sq mi used because all sediment deposited in reservoir 16 was washed to reservoir 6 when dam was breached.
[6] Drainage area of reservoir 10 reduced from 3.19 to 2.09 sq mi by construction of dam 15, May 1953.
[7] No record; runoff estimated to be the same as in remainder of basin.
[8] Highest flow of season; lesser flows not recorded.
[9] Runoff observed prior to failure of dam in July.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*

Reservoir 1

Drainage area.—0.39 sq mi.
Records available.—July 1951 to August 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,620 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 24.0 acre-ft, Apr. 23, 1951; 13.5 acre-ft, Oct. 18, 1955.
Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 45.3	58.1	20.9	0	20.9	53.6
1952						
July 7	[1] 45.3	53.4	6.1	0	6.1	15.6
Aug. 1	48.2	49.2	.7	0	.7	1.8
Aug. 12	48.0	54.3	7.0	0	7.0	17.9
Aug. 25	52.8	53.0	.3	0	.3	.8
Total			14.1	0	14.1	36.1
1953						
July 16–17	[1] 46.5	57.0	13.0	0	13.0	33.3
July 31	55.8	56.3	1.3	0	1.3	3.3
Aug. 11	55.4	56.0	1.4	0	1.4	3.6
Total			15.7	0	15.7	40.2
1954						
July 9	50.5	51.9	1.0	0	1.0	2.6
July 21–22	51.4	55.9	6.9	0	6.9	17.7
July 31	55.4	56.0	1.6	0	1.6	4.1
Aug. 17	54.1	55.8	3.4	0	3.4	8.7
Sept. 12	54.5	55.6	2.3	0	2.3	5.9
Sept. 25	55.1	56.9	5.0	0	5.0	12.8
Total			20.2	0	20.2	51.8
1955						
July 18	50.9	52.7	1.2	0	1.2	3.1
July 22–29	52.0	59.5	15.0	5.4	20.4	52.3
Aug. 4–7	58.2	59.5	1.6	5.2	6.8	17.4
Aug. 13	57.3	58.2	3.3	0	3.3	8.5
Aug. 23	56.6	58.8	6.4	1.0	7.4	19.0
Total			27.5	11.6	39.1	100.3

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 2

Drainage area.—1.09 sq mi.
Records available.—July 1951 to August 1955.
Gage.—Water-stage recorder. Datum of gage is approximately 6,620 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 54.1 acre-ft, Apr. 5, 1951; 45.4 acre-ft, Oct. 15, 1955.
Remarks.—Records good.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 76.4	92.2	21.0	0	21.0	19.3
1952						
July 7	[1] 76.4	84.7	4.1	0	4.1	3.8
Aug. 1	77.7	78.8	.3	0	.3	.3
Aug. 12	77.1	83.8	3.4	0	3.4	3.1
Aug. 25	77.4	83.6	3.1	0	3.1	2.8
Total			10.9	0	10.9	10.0
1953						
July 16–17	[1] 76.5	93.7	26.0	0	26.0	23.8
July 31	86.0	86.5	.4	0	.4	.4
Aug. 11	85.1	87.9	2.6	0	2.6	2.4
Total			29.0	0	29.0	26.6
1954						
July 2	78.6	88.8	6.9	0	6.9	6.3
July 9	87.1	88.4	1.9	0	1.9	1.7
July 21	87.0	87.5	.5	0	.5	.5
July 22	87.5	90.9	6.9	0	6.9	6.3
July 31	87.4	87.6	.2	0	.2	.2
Aug. 17	86.7	87.2	.5	0	.5	.5
Sept. 12	86.1	88.1	2.1	0	2.1	1.9
Sept 25	87.3	90.4	4.9	0	4.9	4.5
Total			23.9	0	23.9	21.9
1955						
July 25	80.2	81.0	.1	0	.1	.1
July 26	81.0	84.9	1.8	0	1.8	1.7
July 27	84.8	87.0	1.6	0	1.6	1.5
July 29	86.7	87.7	.9	0	.9	.8
Aug. 4	87.2	88.9	2.3	0	2.3	2.1
Aug. 6	87.6	92.1	10.0	0	10.0	9.2
Aug. 7	90.3	90.9	1.5	0	1.5	1.4
Aug. 13	87.7	89.7	3.1	0	3.1	2.8
Aug. 18	87.6	88.4	1.1	0	1.1	1.0
Aug. 23	87.7	91.0	5.8	0	5.8	5.3
Total			28.2	0	28.2	25.9

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 3

Drainage area.—0.31 sq mi.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,710 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 5.9 acre-ft, Apr. 1951; 3.2 acre-ft, Oct. 18, 1955.
Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 36.0	47.1	5.3	0	5.3	17.1
1952						
Aug. 1	37.3	41.6	1.2	0	1.2	3.9
Aug. 12	40.6	45.5	2.8	0	2.8	9.0
Aug. 25	44.7	48.7	2.0	2.7	4.7	15.2
Total			6.0	2.7	8.7	28.1
1953						
July 16–17	38.3	48.1	4.2	1.1	5.3	17.1
July 31	46.4	47.4	1.0	0	1.0	3.2
Aug. 11	46.9	48.6	.4	2.4	2.8	9.0
Total			5.6	4.5	9.1	29.3
1954						
July 2	41.4	41.9	.6	0	.6	1.9
July 9	41.7	48.6	3.6	1.7	5.3	17.1
July 21–22	46.6	48.7	.9	6.3	7.2	23.2
July 31	47.3	47.7	.2	.2	.4	1.3
Aug. 17	46.5	47.2	.7	0	.7	2.3
Sept. 12	45.9	47.2	1.1	0	1.1	3.5
Sept. 25	46.5	48.5	1.0	1.9	2.9	9.4
Total			8.1	10.1	18.2	58.7
1955						
July 22–29	41.8	46.8	2.6	0	2.6	8.4
Aug. 4–7	46.4	48.4	.9	1.6	2.5	8.1
Aug. 13	47.4	48.2	1.4	1.2	2.6	8.4
Aug. 23	47.1	48.9	.1	3.8	3.9	12.6
Total			5.0	6.6	11.6	37.5

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 4

Drainage area.—1.42 sq mi.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,750 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 22.1 acre-ft, Apr. 1951; 18.5 acre-ft, Oct. 19, 1955.
Remarks.—Records good, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 38.8	50.1	11.0	0	11.0	7.7
1952						
July 7	[1] 38.8	49.9	9.3	0	9.3	6.5
Aug. 1	46.2	50.3	7.2	0	7.2	5.1
Aug. 12	49.1	52.7	10.0	0	10.0	7.0
Aug. 25	51.2	53.0	6.3	0	6.3	4.4
Total			32.8	0	32.8	23.0
1953						
July 16–17	[1] 40.3	50.8	11.0	0	11.0	7.7
July 31	49.1	51.2	4.9	0	4.9	3.4
Aug. 11	50.2	53.0	8.7	0	8.7	6.1
Total			24.6	0	24.6	17.2
1954						
July 2	[1] 41.6	44.2	.6	0	.6	.4
July 9	43.8	48.5	3.8	0	3.8	2.7
July 21–22	48.1	55.3	15.0	14.0	29.0	20.4
July 31	53.4	53.6	.6	0	.6	.4
Aug. 17	52.0	52.2	.8	0	.8	.6
Sept. 12	50.5	51.7	3.5	0	3.5	2.5
Sept. 25	50.9	52.4	4.4	0	4.4	3.1
Total			28.7	14.0	42.7	30.1
1955						
July 22–29	42.3	43.6	.3	0	.3	.2
Aug. 4–7	43.2	52.4	13.0	0	13.0	9.2
Aug. 13	50.8	51.5	1.8	0	1.8	1.3
Aug. 23	50.5	51.3	1.9	0	1.9	1.3
Total			17.0	0	17.0	12.0

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 5

Drainage area.—1.04 sq mi.
Records available.—July 1951 to Aug. 1955.
Gage.—Water-stage recorder. Datum of gage is approximately 6,850 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 9.2 acre-ft, Apr. 1951; 3.5 acre-ft, Oct. 20, 1955.
Remarks.—Records good, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 44.5	52.6	8.6	1.0	9.6	9.2
1952						
July 7	45.5	52.7	7.8	2.0	9.8	9.4
Aug. 1	48.7	51.8	4.8	0	4.8	4.6
Aug. 12	49.3	53.6	4.5	7.0	11.5	11.0
Aug. 25	49.7	50.8	1.7	0	1.7	1.6
Total			18.8	9.0	27.8	26.6
1953						
July 17	[1] 46.2	51.2	3.9	0	3.9	3.7
July 26	49.5	50.5	1.1	0	1.1	1.1
July 31	49.6	50.4	.8	0	.8	.8
Aug. 11	49.7	50.3	.7	0	.7	.7
Total			6.5	0	6.5	6.3
1954						
July 2	[1] 46.5	49.0	1.3	0	1.3	1.2
July 9	48.7	52.3	4.1	0	4.1	3.9
July 21–22	51.8	54.1	.9	38.0	38.9	37.4
July 31	51.6	52.3	1.3	0	1.3	1.2
Aug. 17	51.0	51.3	.4	0	.4	.4
Sept. 12	50.5	51.6	1.6	0	1.6	1.5
Sept. 25	51.2	52.8	1.9	3.0	4.9	4.7
Total			11.5	41.0	52.5	50.3
1955						
July 22	47.9	48.5	.2	0	.2	.2
July 25	48.2	51.7	3.6	0	3.6	3.5
July 26	51.6	51.9	.8	0	.8	.8
July 27	51.9	52.9	.1	5.7	5.8	5.6
Aug. 4	51.6	52.5	.8	2.3	3.1	3.0
Aug. 6	51.9	52.5	.1	2.3	2.4	2.3
Aug. 7	51.8	52.0	.3	0	.3	.3
Aug. 17	51.7	52.4	.7	1.5	2.2	2.1
Total			6.6	11.8	18.4	17.8

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 6

Drainage area.—3.20 sq mi from Apr. 1951 to May 1954 and from July 23, 1954, to May 1955 while dam for reservoir 17 was breached; 2.64 sq miles from May 1954 to July 22, 1954 and from May 1955 to Sept. 30, 1955.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,700 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 44.9 acre-ft, Apr. 16, 1951; 7.4 acre-ft, Oct. 19, 1955.
Remarks.—Records good, except that those for spill are poor. Outflow temporarily impounded by spreader system below reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Total inflow (acre-ft)	Spill from upstream reservoirs (acre-ft)	Inflow (acre-ft per sq mi)
	Before inflow	After inflow					
1951							
July 31	[1] 43.2	57.0	39.0	0	39.0	1.0	11.9
1952							
July 7	[1] 43.2	58.0	41.0	8.0	49.0	2.0	14.7
Aug. 1	48.0	49.5	1.4	0	1.4	0	.4
Aug. 12	48.3	58.7	38.0	20.0	58.0	7.0	15.9
Aug. 25	48.0	53.8	13.0	0	13.0	0	4.1
Total			93.4	28.0	121.4	9.0	35.1
1953							
July 16–17	[1] 47.5	56.6	28.0	0	28.0	0	8.8
July 26	48.9	51.8	3.4	0	3.4	0	1.1
July 31	51.1	53.4	6.3	0	6.3	0	2.0
Aug. 11	51.3	57.1	30.0	0	30.0	0	9.4
Total			67.7	0	67.7	0	21.3
1954							
July 2	[1] 50.1	54.6	7.7	0	7.7	0	2.9
July 9	50.4	58.7	25.0	22.0	47.0	0	17.8
July 21–22	55.6	59.6	12.0	[2] 118.0	[2] 130.0	56.0	28.0
July 31	57.0	57.5	2.2	2.5	4.7	0	1.5
Aug. 17	57.1	57.3	1.7	0	1.7	0	.5
Sept. 12	55.1	58.0	15.0	11.0	26.0	0	8.1
Sept. 25	56.8	58.5	4.1	20.0	24.1	3.0	6.6
Total			67.7	173.5	241.2	59.0	65.4
1955							
July 22–29	[1] 52.3	57.1	12.0	4.5	16.5	5.7	4.1
Aug. 4–7	56.2	59.7	1.1	99.0	100.1	8.4	34.7
Aug. 13	56.3	57.6	1.1	14.0	15.1	0	5.7
Aug. 23	55.9	56.7	3.7	1.4	5.1	0	1.9
Aug. 24	56.5	56.8	0	2.2	2.2	0	.8
Total			17.9	121.1	139.0	14.1	47.2

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.
[2] Dam for reservoir 17 failed July 22, 1954, emptying 19 acre-ft of water into reservoir 6. Therefore, spill, total inflow, and unit inflow for reservoir 6 are estimated on the basis of records for nearby basins. Reservoir 17 was repaired May 1955.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 7

Drainage area.—1.20 sq mi from Apr. 1951 to Apr. 1953 and from July 10, 1954, to May 1955 while dam for reservoir 16 was breached; 0.50 sq mi from Apr. 1953 to July 9, 1954, and May 1955 to Sept. 30, 1955.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,640 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 15.0 acre-ft, Apr. 9, 1951; 6.9 acre-ft, Oct. 19, 1955.
Remarks.—Records good, except that those for spill are poor. Outflow temporarily impounded by spreader system below reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Total inflow (acre-ft)	Spill from upstream reservoirs (acre-ft)	Inflow (acre-ft per sq mi)
	Before inflow	After inflow					
1951							
July 31	83.1	95.9	12.0	14.0	26.0	0	21.6
1952							
July 7	[1] 83.1	95.0	12.0	6.0	18.0	0	15.0
Aug. 1	88.4	89.0	.3	0	.3	0	.3
Aug. 12	88.6	91.5	2.4	0	2.4	0	2.0
Aug. 25	89.2	93.4	6.9	0	6.9	0	5.7
Total			21.6	6.0	27.6	0	23.0
1953							
July 16–17	[1] 84.0	93.2	7.2	0	7.2	0	14.4
July 31	88.0	91.8	2.9	0	2.9	0	5.8
Aug. 11	88.2	93.0	5.3	0	5.3	0	10.6
Total			15.4	0	15.4	0	30.8
1954							
July 2	85.0	89.8	1.8	0	1.8	0	3.6
July 9	89.1	95.8	8.1	[2] 20.8	[2] 28.9	22.8	[2] 21.0
July 21–22	89.1	95.8	8.4	28.0	36.4	0	30.0
July 31			0	0	0	0	0
Aug. 17	89.4	89.6	.1	0	.1	0	.1
Sept. 12	88.8	94.0	8.3	0	8.3	0	6.9
Sept. 25	89.8	94.9	8.1	8.0	16.1	0	13.3
Total			34.8	56.8	91.6	22.8	74.9
1955							
July 18	[1] 86.9	89.9	1.1	0	1.1	0	2.2
July 22–29	89.1	90.7	.9	0	.9	0	1.8
Aug. 4–7	89.7	96.4	6.1	18.0	24.1	0	48.2
Aug. 13	89.9	93.3	4.1	0	4.1	0	8.2
Aug. 23	89.7	94.4	6.6	1.4	8.0	0	16.0
Aug. 24	90.2	90.6	.2	0	.2	0	.4
Sept. 2	90.0	90.4	.3	0	.3	0	.6
Total			19.3	19.4	38.7	0	77.4

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.
[2] Dam for reservoir 16 failed July 9, 1954, emptying 23 acre-ft of water into reservoir 7. Therefore, spill, total inflow, and unit inflow for reservoir 7 have been estimated on the basis of records for nearby basins. Reservoir 16 was repaired May 1955.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 9

Drainage area.—0.17 sq mi.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,760 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 4.6 acre-ft, Apr. 6, 1951; 3.1 acre-ft, Oct. 17, 1955.
Remarks.—Records good, except that those for spill are poor. Outflow temporarily impounded by spreader system below reservoir.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 67.5	75.7	4.2	0	4.2	24.7
1952						
July 7	[1] 67.5	73.9	2.3	0	2.3	13.5
Aug. 12	69.4	75.6	3.9	0	3.9	22.9
Aug. 25	70.8	74.8	2.6	0	2.6	15.3
Total			8.8	0	8.8	51.7
1953						
July 16–17	[1] 68.0	73.4	1.7	0	1.7	10.0
July 31	70.8	72.8	.9	0	.9	5.3
Aug. 11	71.6	74.5	1.8	0	1.8	10.6
Total			4.4	0	4.4	25.9
1954						
July 2	[1] 68.4	69.7	.1	0	.1	.6
July 9	69.3	75.9	3.8	0	3.8	22.4
July 21–22	72.8	77.1	2.7	3.4	6.1	35.8
Aug. 17	72.8	73.4	.4	0	.4	2.4
Sept. 12	70.7	73.0	1.0	0	1.0	5.9
Sept. 25	71.7	75.3	2.5	0	2.5	14.7
Total			10.5	3.4	13.9	81.8
1955						
July 18	[1] 69.6	72.2	.6	0	.6	3.5
July 22–29	70.8	72.2	.5	0	.5	2.9
Aug. 4–7	71.2	77.4	2.9	3.0	5.9	34.7
Aug. 23	74.0	76.2	1.7	.3	2.0	11.8
Sept. 2	75.2	75.7	.5	0	.5	2.9
Total			6.2	3.3	9.5	55.8

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 10

Drainage area.—3.19 sq mi from April 1951 to May 1953 and 2.09 sq mi thereafter.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,700 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 48.6 acre-ft, Apr. 1951; 37.2 acre-ft, Oct. 17, 1955.
Remarks.—Records good, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Total inflow (acre-ft)	Spill from upstream reservoirs (acre-ft)	Inflow (acre-ft per sq mi)
	Before inflow	After inflow					
1951							
July 31	[1] 39.8	59.3	47.0	1.0	48.0	0	15.0
1952							
July 7	46.0	59.6	45.0	4.0	49.0	0	15.4
Aug. 12	48.6	60.0	43.0	10.0	53.0	0	16.6
Aug. 25	49.6	52.6	3.8	0	3.8	0	1.2
Total			91.8	14.0	105.8	0	33.2
1953							
July 16–17	43.7	54.4	11.0	0	11.0	0	5.3
July 31	49.8	51.9	1.8	0	1.8	0	.9
Aug. 11	49.9	53.6	5.1	0	5.1	0	2.4
Total			17.9	0	17.9	0	8.6
1954							
July 2	45.0	46.5	.5	0	.5	0	.2
July 9	46.0	57.8	29.0	0	29.0	0	13.9
July 21–22	50.8	60.2	39.0	20.0	59.0	0	28.2
July 31	50.7	51.5	.8	0	.8	0	.4
Aug. 17	50.7	51.3	.6	0	.6	0	.3
Sept. 12	50.2	56.1	15.0	0	15.0	0	7.2
Sept. 25	51.0	52.6	2.0	0	2.0	0	1.0
Total			86.9	20.0	106.9	0	51.2
1955							
July 18	46.2	54.0	7.2	0	7.2	0	3.4
July 22–29	50.2	56.4	16.0	0	16.0	0	7.7
Aug. 4–7	50.4	59.8	37.0	7.1	44.1	0	21.1
Aug. 13	50.5	53.6	4.0	0	4.0	0	1.9
Aug. 18	50.4	57.0	20.0	0	20.0	0	9.6
Aug. 24	51.4	54.5	6.2	0	6.2	0	3.0
Total			90.4	7.1	97.5	0	46.7

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 11

Drainage area.—3.00 sq mi.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,590 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 166.8 acre-ft, Apr. 13, 1951; 107.3 acre-ft, Oct. 16, 1955.
Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Total inflow (acre-ft)	Spill from upstream reservoirs (acre-ft)	Inflow (acre-ft per sq mi)
	Before inflow	After inflow					
1951							
July 31	[1] 70.2	89.3	119.0	0	119.0	1.0	39.3
1952							
July 7	[1] 70.2	89.4	118.0	0	118.0	4.0	38.0
Aug. 12	79.2	89.6	102.0	0	102.0	10.0	30.7
Aug. 25	84.4	85.1	7.3	0	7.3	0	2.4
Total			227.3	0	227.3	14.0	71.1
1953							
July 16–17	[1] 73.8	87.4	61.0	0	61.0	0	20.3
July 26	80.0	82.0	9.6	0	9.6	0	3.2
July 31	80.2	83.3	17.0	0	17.0	0	5.7
Aug. 11	81.3	83.1	12.0	0	12.0	0	4.0
Total			99.6	0	99.6	0	33.2
1954							
July 9	[1] 75.9	82.1	17.0	0	17.0	0	5.7
July 21–22	80.8	88.5	70.0	0	70.0	20.0	16.6
July 31	81.3	82.8	7.5	0	7.5	0	2.5
Aug. 17	80.4	82.2	7.6	0	7.6	0	2.5
Sept. 12	80.0	82.8	12.0	0	12.0	0	4.0
Sept. 25	81.0	86.2	24.0	0	24.0	0	8.0
Total			138.1	0	138.1	20.0	39.3
1955							
July 18	[1] 78.3	81.4	8.3	0	8.3	0	2.8
July 22–29	80.4	88.6	84.0	0	84.0	0	28.0
Aug. 4–7	81.2	89.2	75.0	0	75.0	7.1	2.6
Aug. 13	81.1	83.9	13.0	0	13.0	0	4.3
Aug. 16	83.7	84.5	6.8	0	6.8	0	2.3
Aug. 23	84.0	87.9	40.0	0	40.0	0	13.3
Total			227.1	0	227.1	7.1	73.3

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 12

Drainage area.—7.44 sq mi.
Records available.—July 1951, July 1953 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,600 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 323.6 acre-ft, July 19, 1951; 174.0 acre-ft, Oct. 14, 1955.
Remarks.—Records fair, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Total inflow (acre-ft)	Spill from upstream reservoirs (acre-ft)	Inflow (acre-ft per sq mi)
	Before inflow	After inflow					
1951							
July 31	[1] 37.0	55.3	282.0	0	282.0	11.0	36.4
1952 [2]							
1953							
July 16–17	40.1	55.3	246.0	0	246.0	2.0	32.8
July 31	52.2	52.7	15.0	0	15.0	0	2.0
Aug. 11	51.6	55.3	116.0	0	116.0	5.0	14.9
Total			377.0	0	377.0	7.0	49.7
1954							
July 2	[1] 42.4	45.9	10.0	0	10.0	0	1.3
July 9	45.6	51.8	83.0	0	83.0	2.0	10.9
July 21–22	49.8	56.8	169.0	72.0	241.0	68.0	23.3
July 31	53.6	54.1	15.0	0	15.0	1.0	1.9
Aug. 17	48.2	50.2	29.0	0	29.0	0	3.9
Sept. 12	46.8	52.0	81.0	0	81.0	4.0	10.3
Sept. 25	47.3	52.3	88.0	0	88.0	13.0	10.1
Total			475.0	72.0	547.0	88.0	61.7
1955							
July 22–29	[1] 45.3	52.5	85.0	0	85.0	0	11.4
Aug. 4–7	49.2	57.1	160.0	71.0	231.0	3.0	30.6
Aug. 13	54.9	55.5	21.0	0	21.0	3.3	2.4
Aug. 23	53.6	54.8	36.0	0	36.0	8.2	3.7
Total			302.0	71.0	373.0	14.5	48.1

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.
[2] No record.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 13

Drainage area.—0.45 sq mi.
Records available.—July 1951 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,670 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 7.4 acre-ft, Apr. 23, 1951; 1.9 acre-ft, Oct. 18, 1955.
Remarks.—Records fair, except that those for spill are poor.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1951						
July 31	[1] 45.0	52.0	6.6	0	6.6	14.7
1952						
July 7	[1] 45.0	46.8	.6	0	.6	1.3
Aug. 1	[1] 45.0	46.8	.6	0	.6	1.3
Aug. 12	45.4	47.9	1.1	0	1.1	2.4
Aug. 25	47.2	52.4	6.0	1.0	7.0	15.5
Total			8.3	1.0	9.3	20.5
1953						
July 16–17	[1] 45.6	52.4	5.4	1.0	6.4	14.2
July 31	49.7	51.2	2.0	0	2.0	4.4
Aug. 11	50.2	53.2	1.1	3.0	4.1	9.1
Total			8.5	4.0	12.5	27.7
1954						
July 2	[1] 47.7	50.3	1.1	0	1.1	2.4
July 9	49.2	50.2	.6	0	.6	1.3
July 21–22	49.2	52.7	2.4	1.6	4.0	8.9
July 31	50.7	51.2	.5	0	.5	1.1
Aug. 17	49.4	50.2	.5	0	.5	1.1
Sept. 12	48.8	50.6	1.0	0	1.0	2.2
Sept. 25	49.9	52.9	2.1	1.9	4.0	8.9
Total			8.2	3.5	11.7	25.9
1955						
July 22–29	[1] 48.5	50.0	.6	0	.6	1.3
Aug. 4–7	49.6	52.8	1.9	1.5	3.4	7.6
Aug. 13	51.8	52.9	.2	2.1	2.3	5.1
Aug. 23	51.4	53.5	.4	4.4	4.8	10.7
Total			3.1	8.0	11.1	24.7

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 15

Drainage area.—1.10 sq mi.
Records available.—July 1953 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,750 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original 17.9 acre-ft, Dec. 23, 1953, capacity unchanged, Oct. 20, 1955.
Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
July 16-17 [1]	[2] 56.3	58.5	0.7	0	0.7	0.6
1954						
July 9	[2] 56.3	61.3	5.4	0	5.4	4.9
July 21-22	[2] 56.4	59.0	1.1	0	1.1	1.0
Total			6.5	0	6.5	5.9
1955						
July 22-29	[2] 56.3	59.3	1.5	0	1.5	1.4
Aug. 4-7	[2] 56.3	57.8	.3	0	.3	.3
Aug. 13	[2] 56.3	57.3	.1	0	.1	.1
Aug. 23	[2] 56.3	58.3	.6	0	.6	.5
Total			2.5	0	2.5	2.3

[1] The flow of July 16-17 was the largest of the year. Lesser flows were not recorded.
[2] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.

Reservoir 16

Drainage area.—0.70 sq mi.
Records available.—July 1953 to July 1954, July 1955 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,780 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 28.9 acre-ft, Apr. 30, 1955, 27.6 acre-ft, Oct. 20, 1955.
Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1953						
July 16-17 [1]	[2] 52.1	62.5	9.3	0	9.3	13.3
1954						
July 2	54.9	58.1	2.8	0	2.8	4.0
July 9 [3]	57.7	66.9	20.0	0	20.0	28.6
1955						
July 22-29	[2] 53.0	58.1	2.4	0	2.4	3.4
Aug. 4-7	57.5	67.5	22.0	0	22.0	31.4
Aug. 13	60.6	62.2	2.6	0	2.6	3.7
Aug. 18	60.5	63.5	5.1	0	5.1	7.3
Aug. 24	61.0	61.8	1.4	0	1.4	2.0
Sept. 2	60.6	61.2	1.1	0	1.1	1.6
Total			34.6	0	34.6	49.4

[1] The flow of July 16-17 was the largest of the year. Lesser flows were not recorded.
[2] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.
[3] Totals are not shown because of incomplete records owing to a dam failure, which released 22.8 acre-ft of water to reservoir 7.

TABLE 8.—*Storm runoff measured in reservoirs in Cornfield Wash*—Continued

Reservoir 17

Drainage area.—0.56 sq mi.
Records available.—July 1954, July 1955 to Aug. 1955.
Gage.—Crest-stage gage. Datum of gage is approximately 6,890 ft above mean sea level.
Runoff and discharge determinations.—Contents of reservoir and volume of inflow and outflow computed from a stage-capacity curve of the reservoir.
Capacity.—Original, 18.3 acre-ft, Apr. 29, 1955, 17.6 acre-ft, Oct. 19, 1955.
Remarks.—Records fair.

Date of flow	Gage height (feet)		Inflow stored (acre-ft)	Spill (acre-ft)	Inflow	
	Before inflow	After inflow			Total (acre-ft)	Acre-ft per sq mi
1954						
July 2	[1] 61.1	63.9	1.0	0	1.0	1.8
July 9	62.1	66.0	2.4	0	2.4	4.3
July 21–22 [2]	61.8	73.2	18.0	.5	18.5	34.4
1955						
July 22–29	[1] 61.1	67.8	5.5	0	5.5	9.8
Aug. 4–7	64.8	73.9	16.0	3.8	19.8	35.4
Aug. 13	64.8	65.5	.5	0	.5	.9
Aug. 24	64.8	67.4	2.5	0	2.5	4.5
Total			24.5	3.8	28.3	50.6

[1] Reservoir dry at beginning of flow. Elevation before inflow is the elevation of the low point of the reservoir.
[2] Totals are not shown because of incomplete records owing to a dam failure, which released 18 acre-ft of water to reservoir 6.

The volume of spill for periods when overflow occurs at a reservoir has been computed in several ways (Langbein and others, 1951, p. 9; Culler and Peterson, 1953, p. 22). For this investigation it was computed by means of the following equation:

$$V=S\left[1+\frac{CQ\sqrt{A}}{S+S_1}\right], \qquad (1)$$

in which

V=volume of spill, in acre-feet
A=drainage area, in square miles
S=surcharge: the volume of water temporarily stored in the reservoir above the spillway crest, in acre-feet
S_1=volume of runoff impounded below spillway level, in acre-feet
Q=maximum rate of spill, in cubic feet per second
C=a coefficient relating the volume and rate of spill to the surcharge for each reservoir.

The equation is derived as follows: Assume a reservoir is filled to spillway level at the beginning of inflow. The outflow hydrograph curve would then be of the form shown in figure 17. If the volume of flow represented by the shaded area of figure 17 is designated as X, then the volume of spill equals X plus surcharge, or $V=S+X$. A first approximation of X would be the triangular area $Qt/2$, in which t is the duration of inflow. If X is expressed in acre-feet, Q in

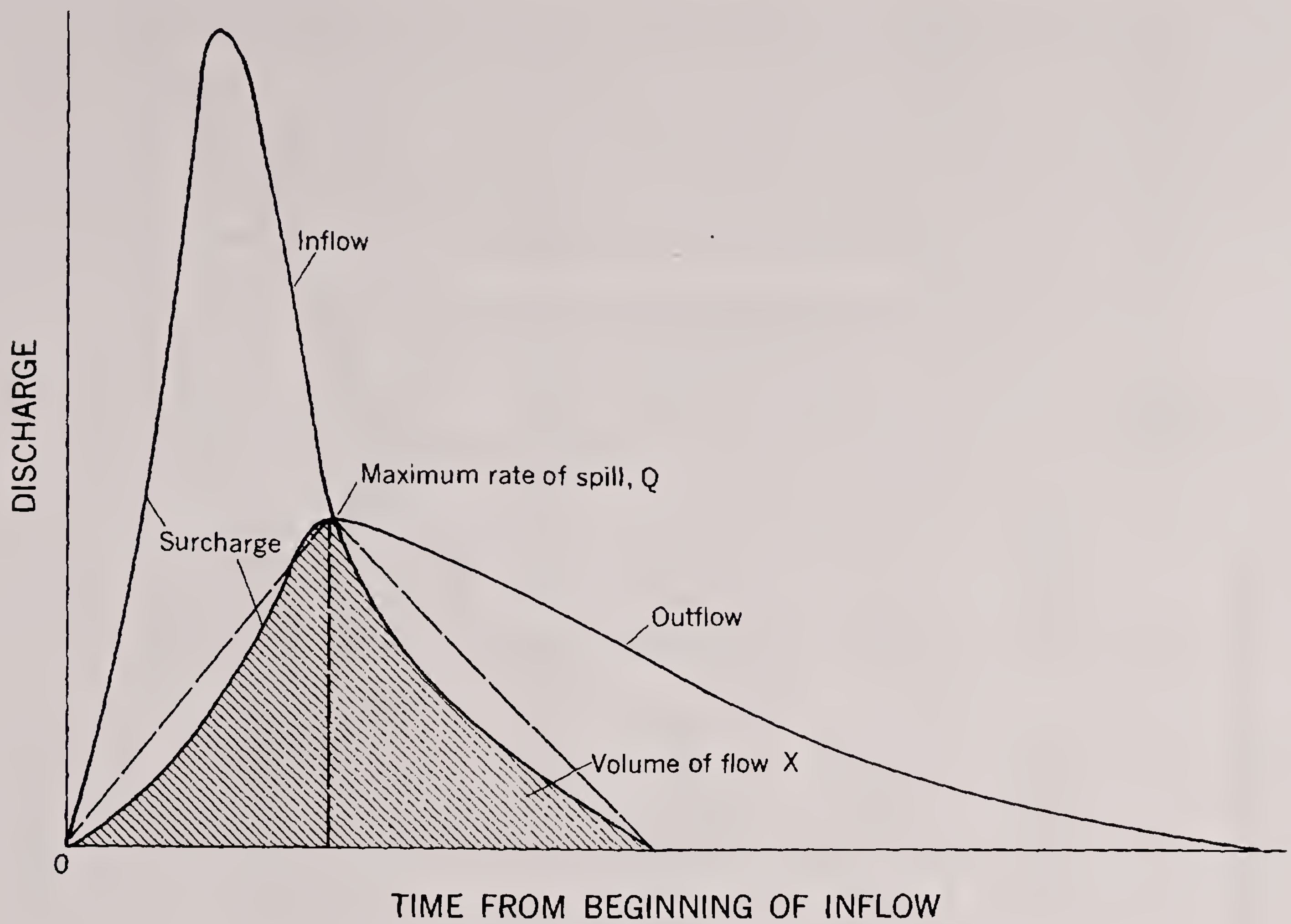

FIGURE 17.—Theoretical hydrograph of reservoir inflow and outflow while spilling.

cubic feet per second, and t in hours, then $X=0.0826\ (Qt/2)$, or 0.041 Qt. If 0.041 t were replaced by a, then

$$V=S+aQ. \tag{2}$$

Twelve floods were recorded at Cornfield Wash reservoir 2 during 1954 and 1955. The duration of inflow, t, ranged from 1.6 to 7.0 hours; hence, a in equation 2 would range from 0.067 to 0.29.

Because of the shape of the hydrographs, the first approximation of X described above would probably be too large, and a in equation 2 should be replaced by a lesser coefficient b or,

$$V=S+bQ \tag{3}$$

The runoff data at reservoir 2 provide a means for computing values of b for the 12 floods.

In making this computation it was assumed that reservoir 2 was full at the start of each flood and that the entire volume of inflow was spilled (actually this reservoir has never spilled). Each of the 12 floods was routed through the reservoir to determine maximum reservoir stage and outflow. Thus, in equation 3, Q, V, and S were known, and $b=(V-S)/Q$. Table 9 summarizes the data used to compute b. For the period 1954–55, b ranged from 0.02 to 0.19 at reservoir 2. The mean value of b, taken as the slope of the curve on figure 18, was 0.044. Thus, in general $V=S+0.044Q$ at reservoir 2, assuming that the reservoir is full at the start of each flood.

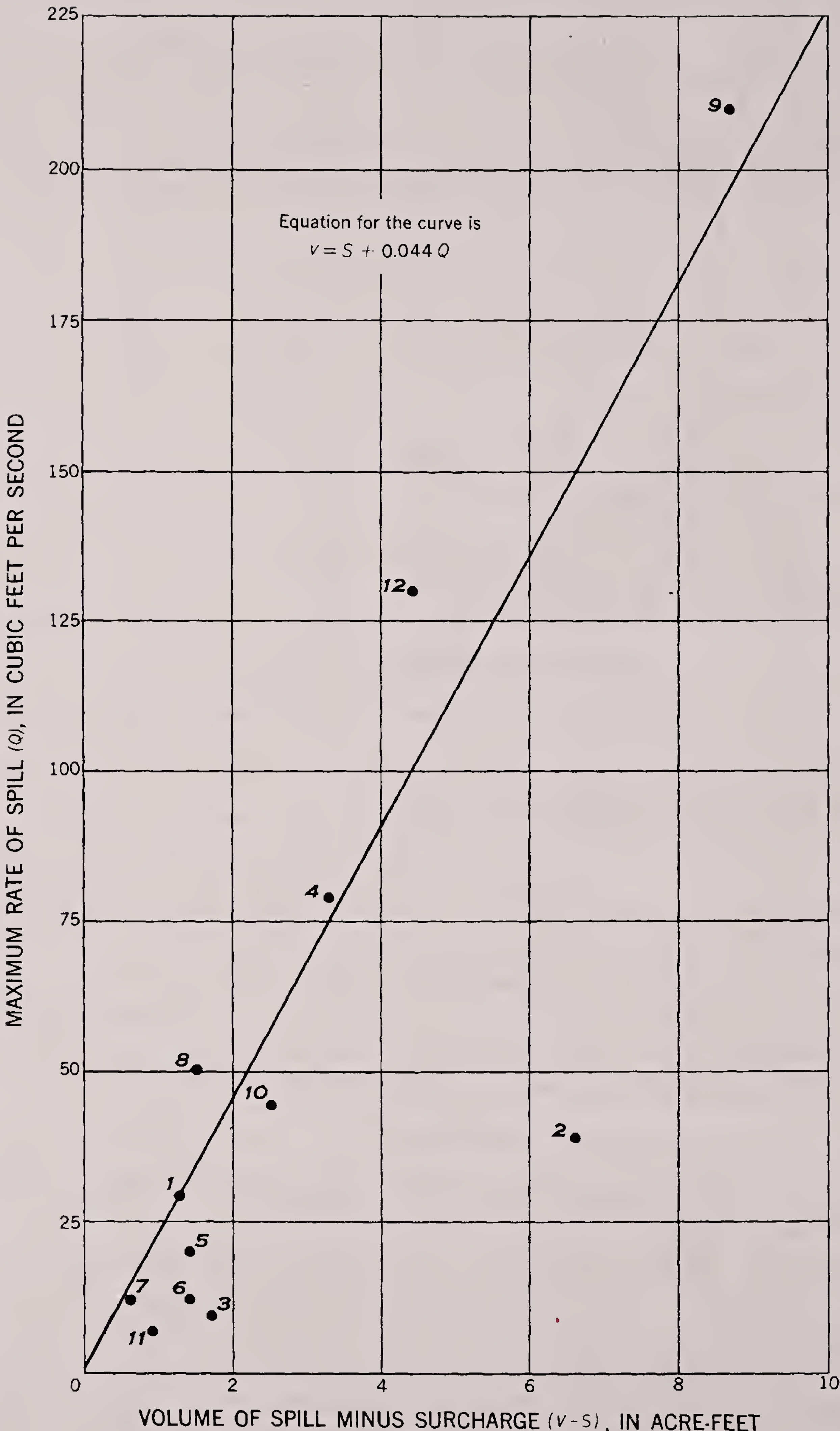

FIGURE 18.—Diagram for determining average value of coefficient b. Numbers indicate floods referred to in table 9.

In applying equation 2 to other Cornfield Wash reservoirs, two more factors, drainage area and reservoir capacity below spillway at time of inflow, must be considered. The drainage area of reservoir 2 is 1.09 square miles. As b is proportional to the duration of inflow, which is roughly proportional to $\sqrt{A}$ for a given storm, equation 2 can be written $V=S+C\sqrt{A}\,Q$, in which $C=b/\sqrt{1.09}$.

TABLE 9.—*Computation of* b *in the equation* V=S+bQ *for reservoir 2*

No. on fig. 18	Date of flood	$V-S$ (acre-ft)	Q (cfs)	b	Duration of inflow, t (hr)
	1954				
1	July 9	1.25	28.4	0.044	1.6
2	July 21 and 22	6.61	38.1	.173	7.0
3	Sept. 12	1.68	8.7	.193	5.3
4	Sept. 25	3.29	78.5	.042	2.7
	1955				
5	July 26	1.39	18.7	.074	3.6
6	July 27	1.39	12.4	.112	8.8
7	July 29	.62	12.0	.052	2.5
8	Aug. 4	1.51	49.9	.030	2.0
9	Aug. 6	8.68	210	.041	1.9
10	Aug. 13	2.50	43.8	.057	2.3
11	Aug. 18	.92	7.0	.131	2.2
12	Aug. 23	4.41	130	.034	2.3

If a reservoir is empty or only partly filled at the beginning of inflow, the quantity $C\sqrt{A}\ Q$ must be multiplied by some value less than 1, as the time from beginning of outflow to end of inflow will be less than the duration of inflow, t. The following coefficient was used: $S/(S+S_1)$, in which S is the surcharge and S_1 is the amount of floodwater stored below the spillway. The final equation then becomes

$$V=S+\frac{S}{S+S_1}CQ\sqrt{A}=S\left[1+\frac{CQ\sqrt{A}}{S+S_1}\right].$$

For reservoir spill, 1954–55, the coefficient C was determined for each flood at reservoir 2, and the same value was used at other reservoirs for floods of the same date. For the period 1951–53, the average value of C at reservoir 2, or $0.044/\sqrt{1.09}=0.042$, was used at all the reservoirs.

Quantities S and S_1 are fixed by the reservoir stage record. The maximum spillway discharge, Q, was obtained from a spillway rating curve based on the broad-crested weir formula (Langbein and others, 1951, p. 9) $Q=2.5\ BH^{3/2}$, in which

Q=spillway discharge, in cubic feet per second

B=width of spillway, in feet

H=maximum depth of water over spillway, in feet.

Large-scale detailed topographic sketches of all reservoir spillways were made. Accurate spillway control sections were drawn on the basis of these sketches and used in the above weir formula.

It might be thought that equation 1 could be checked where reservoirs are in tandem and spill from one reservoir is impounded in the next one downstream. However, the rainfall-runoff relationship for individual storms is so variable that it does not seem possible to distinguish with requisite accuracy between the volume spilled from an upstream reservoir and the runoff from the uncontrolled drainage area between reservoirs.

Except for reservoir 2, which has never spilled, only reservoir 5 was equipped with a water-stage recorder during the summer of 1955. This reservoir spilled four times that summer. The spill, in acre-feet, recorded by the stage graph is compared below with spill computed by means of equation 1.

Date of spill	Recorded spill (acre-feet)	Spill computed by equation 1 (acre-feet)
1955		
July 27	5. 7	8. 5
August 4	2. 3	1. 4
August 6	2. 3	1. 5
August 17	1. 5	1. 4
Total	11. 8	12. 8

The total spill from reservoir 5 in 1955 as computed by equation 1 is 8.5 percent greater than the recorded spill. Additional water-stage recording gages are to be installed at Cornfield Wash in the future, and further checks of equation 1 can be made.

RELATION OF RUNOFF TO PRECIPITATION

The erratic nature of the rainfall-runoff relationship among the individual reservoir drainage basins in the Cornfield Wash area is evident in figures 13–15. For individual storms the relationship appears to be extremely vague; but for seasonal precipitation and total runoff from the entire area, the relationship appears to be fairly constant, as shown in table 10.

TABLE 10.—*Relation between precipitation and runoff during the warm summer season*

Year	Precipitation (inches)	Runoff (inches)	Ratio of runoff to precipitation
1951	3. 91	0. 48	0. 12
1952	7. 05	. 69	. 10
1953	4. 79	. 57	. 12
1954	9. 00	. 97	. 11
1955	7. 47	. 87	. 12

No infiltration measurements were made in the Cornfield Wash basin, but the 5-year runoff pattern indicates fairly uniform infiltration over the major part of the basin. Marked deviations occurred along the east side and in the extreme northwest corner above reservoir 15, as indicated by the 2-year record obtained at this reservoir (see table 8). The average annual runoff, in acre-feet per square mile, for the 5-year period in each of the drainage basins is shown

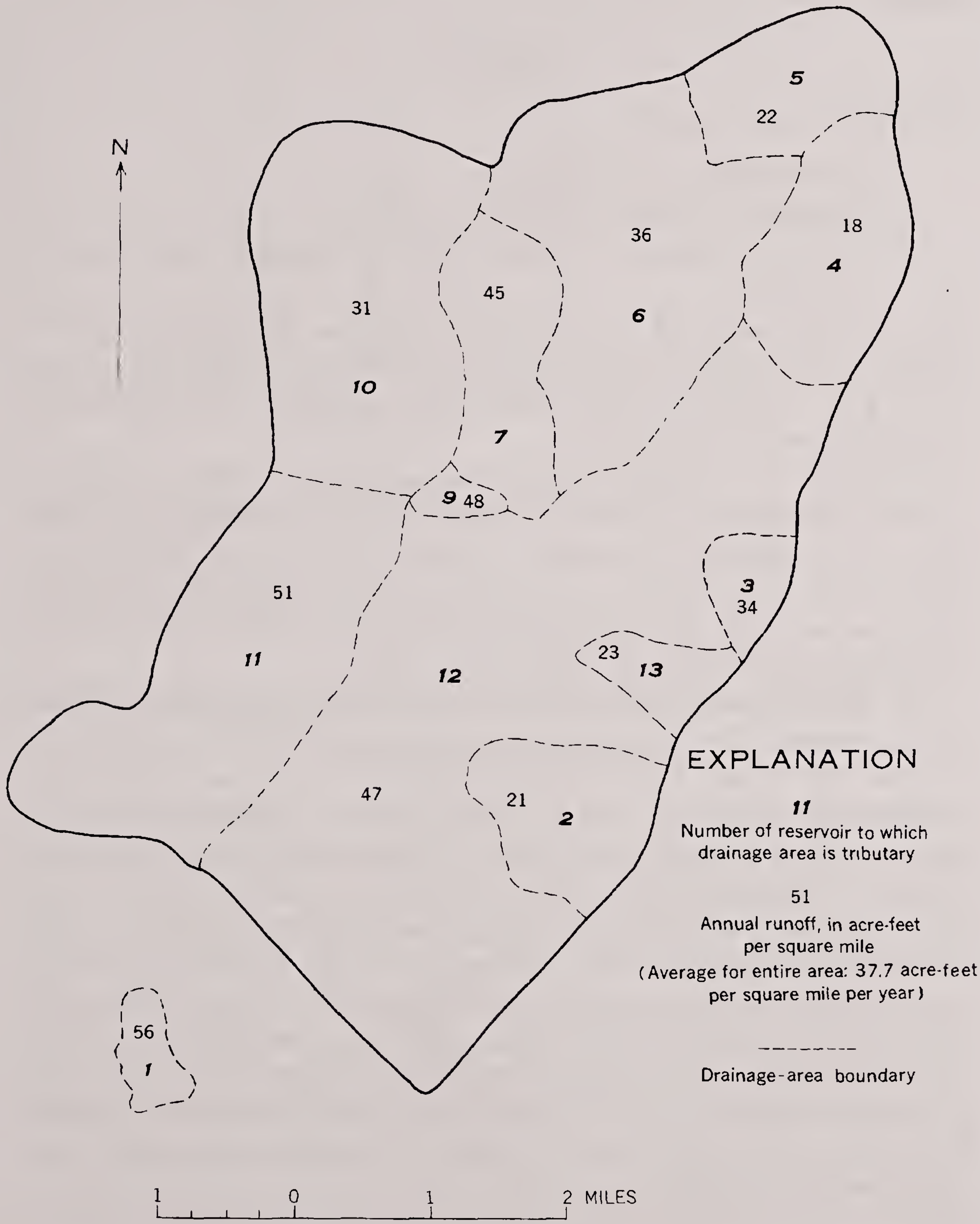

FIGURE 19.—Average annual runoff, Cornfield Wash, 1951–55, in acre-feet per square mile.

on figure 19 (reservoir 6 includes runoff from above reservoir 17, reservoir 7 includes runoff from above reservoir 16, and reservoir 10 includes runoff from above reservoir 15.

A study was made of the largest annual flood volumes for reservoirs 1 to 13 to determine their probable range. A mean annual flood-frequency curve was prepared for each reservoir by plotting the flood volume against its recurrence interval on frequency charts (Powell, 1943). The recurrence interval was computed by means of the formula:

$$T=\frac{N+1}{M}$$

in which

T=recurrence interval, in years
N=number of years of record
M=order number of the flood, with the largest flood assigned No. 1.

The probable range of the mean annual flood was taken from the frequency curve with the upper and lower limits at recurrence intervals of 4.0 and 1.5 years. These mean flood ranges are plotted against drainage areas on figure 20.

The points for Cornfield Wash plot similarly to those in the relationship developed by Kennon (1954) for the San Pedro and Santa Cruz River basins in southern Arizona; but they indicate considerably more runoff than do the points in the relationship developed in the same study for western New Mexico, which summarizes all available runoff records in that area to 1952.

The 1952 curve relating mean annual flood volume to drainage area in western New Mexico was based on relatively few streamflow records. Of those, only 14 records from 5 to 12 years long were available for ephemeral streams draining areas of less than 10 square miles (4 of the records were collected in the San Simon Valley near Safford, Ariz., and 3 on the Montano Grant near Albuquerque, 2 near Santa Fe, and 5 at Mexican Springs near Gallup, N. Mex.). Furthermore, these records were collected in only 3 small but widely scattered basins in New Mexico: In light of the variations in soil, relief, and storm rainfall in New Mexico, considerable variation might be expected in runoff among small drainage basins; therefore, it is not surprising that the mean annual flood volume in Cornfield Wash differs distinctly from the average defined by the meager records available in 1952.

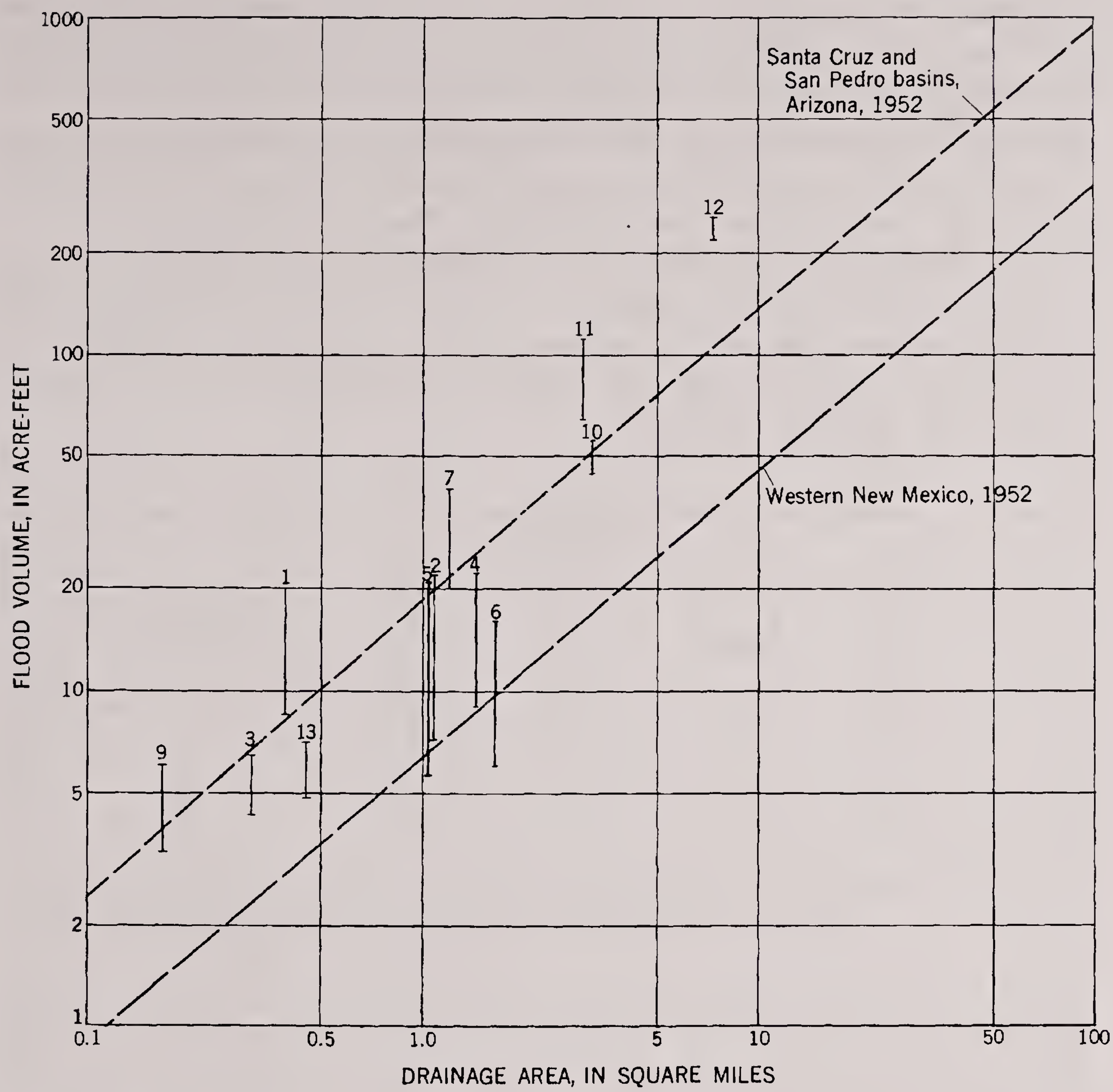

FIGURE 20.—Relation between volume of mean annual flood and drainage area. The vertical lines represent the probable range of mean annual flood volumes at Cornfield Wash reservoirs 1–13.

SEDIMENTATION

The trap efficiency of the reservoirs is not known. Reservoir 4 probably has the highest efficiency, approaching 100 percent, since it has no outlet pipe and has spilled but once. No information is available on the amount of sediment passing out of the reservoirs through outlet pipes during periods of inflow. Four samples of pipe discharge were collected August 24, 1955, at reservoirs 2, 10, 12, and 16 after inflow had stopped. The respective sediment concentrations were found to be 661, 418, 104, and 317 ppm (parts per million), indicating that very little sediment leaves the reservoirs in discharged water after inflow ceases.

Originally, there was an appreciable storage volume in the borrow pit dug considerably lower than the outlet pipe at each retarding

reservoir, and a pond of significant size would result before pipe outflow began. Under these conditions, it would appear that all bedload and the heavier suspended sediments would remain in the pond and only some of the fine clays would leave the reservoir. The "permanent" storage pits have gradually been filling with sediments, although none of these was completely filled as of October 1955.

The average annual accretion of sediment in each of the reservoirs is summarized, together with the annual runoff, in table 7. The average sediment deposition at each of the reservoirs during the 5-year period, 1951–55, and the ratio of sediment volume to inflow volume are given in table 11.

Table 11.—*Average annual sediment accumulation in Cornfield Wash reservoirs, 1951–55*

Reservoir	Average annual sediment accumulation	
	Acre-ft per sq mi	Ratio to runoff volume
1	5. 5	0. 10
2	1. 7	. 08
3	1. 7	. 05
4	. 5	. 03
5	1. 0	. 04
6	[1] 2. 4	[1] . 07
7	[1] 2. 3	[1] . 05
9	2. 1	. 04
10	[1] 1. 0	[1] . 03
11	4. 0	. 08
12	4. 3	. 09
13	3. 2	. 14
Mean for basin	2. 86	. 075

[1] Sediment and inflow of upstream reservoirs included.

Table 11 shows that unit sediment accumulation at the several reservoirs differs considerably more than the ratio of the sediment volume to runoff volume. Sediment transport is known to be influenced by both the rate and volume of runoff; but because runoff is being measured volumetrically and no data are available on discharge rates, the only relationship that can be analyzed here is that between sediment volume and runoff volume.

The ratio of sediment volume to runoff volume by years is shown in table 12. In some reservoirs, notably 6, 7, 10, and 12, the ratio is fairly constant from year to year, but in others it varies considerably. Although the data on sediment accumulation are not as accurate as might have been desired, the errors are believed to be small in relation to the differences shown among the observation reservoirs. The differences may be due to the physical characteristics of

the individual drainage basins, the effects of the type and intensity of rainfall, and moisture conditions prior to storms, which were not the same for all runoff events. It will be noted that the average ratio has not significantly decreased with time, suggesting that trap efficiency has not appreciably changed in the first 5 years.

TABLE 12.—*Ratio of sediment volume to reservoir inflow volume*

Reservoir	Annual				Period 1951–55
	1951	1952–53 [1]	1954	1955	
1	0.04	0.16	0.05	0.11	0.10
2	.10	.11	.004	.08	.08
3	.02	.10	.03	.03	.05
4	0	.04	.03	0	.03
5	.06	.07	.01	.06	.04
6	.08	.06	[2] .08	[2] .07	[2] .07
7	.10	.05	[2] .04	[2] .04	[2] .05
9	.10	.02	.05	.04	.04
10	.04	[2] .04	[2] 0	[2] .05	[2] .03
11	.13	.06	.12	.06	.08
12	.08	.10	.10	.09	.09
13	.08	.20	.08	.11	.14
Average	.069	.084	.049	.062	.067

[1] The sediment surveys of 1952 are considered inadequate; those of 1953 were complete. Hence, 1952 and 1953 are treated together in making sediment analyses.
[2] Inflow and sediment of upstream reservoir included.

The highest ratios of sediment volume to inflow volume are found in reservoirs 1 and 13 (see table 12). The drainage area above reservoir 1 is the steepest of the group, vegetation density is generally the lowest in the area, and the entire basin shows evidence of heavy sheet and gully erosion. High-intensity rainfall on bare prewetted soils of this basin would be expected to result in very much movement of sediment. The drainage area above reservoir 13 likewise shows evidence of much sediment yield. The channel above the reservoir is gullied for two-thirds of its length, with the result that all sediment reaching the channel is funneled directly to the reservoir with no opportunity for deposition along the channel (see pl. 10A).

The gullied channels above reservoirs 11 and 12 probably account for the high ratio of sediment to inflow for those reservoirs. Both receive spill and open-pipe discharge from upstream structures. This relatively clear discharge could undoubtedly again pick up a sediment load from the bottom and sides of the channel on its course downstream. Discharge from reservoirs 6, 7, and 9 passes through the spreading area below reservoir 8. Storage behind the dikes results in some loss of water and some sediment deposition, but the overall effect of spreading does not appear to have had any significant effect on total runoff and sediment reaching reservoir 12.

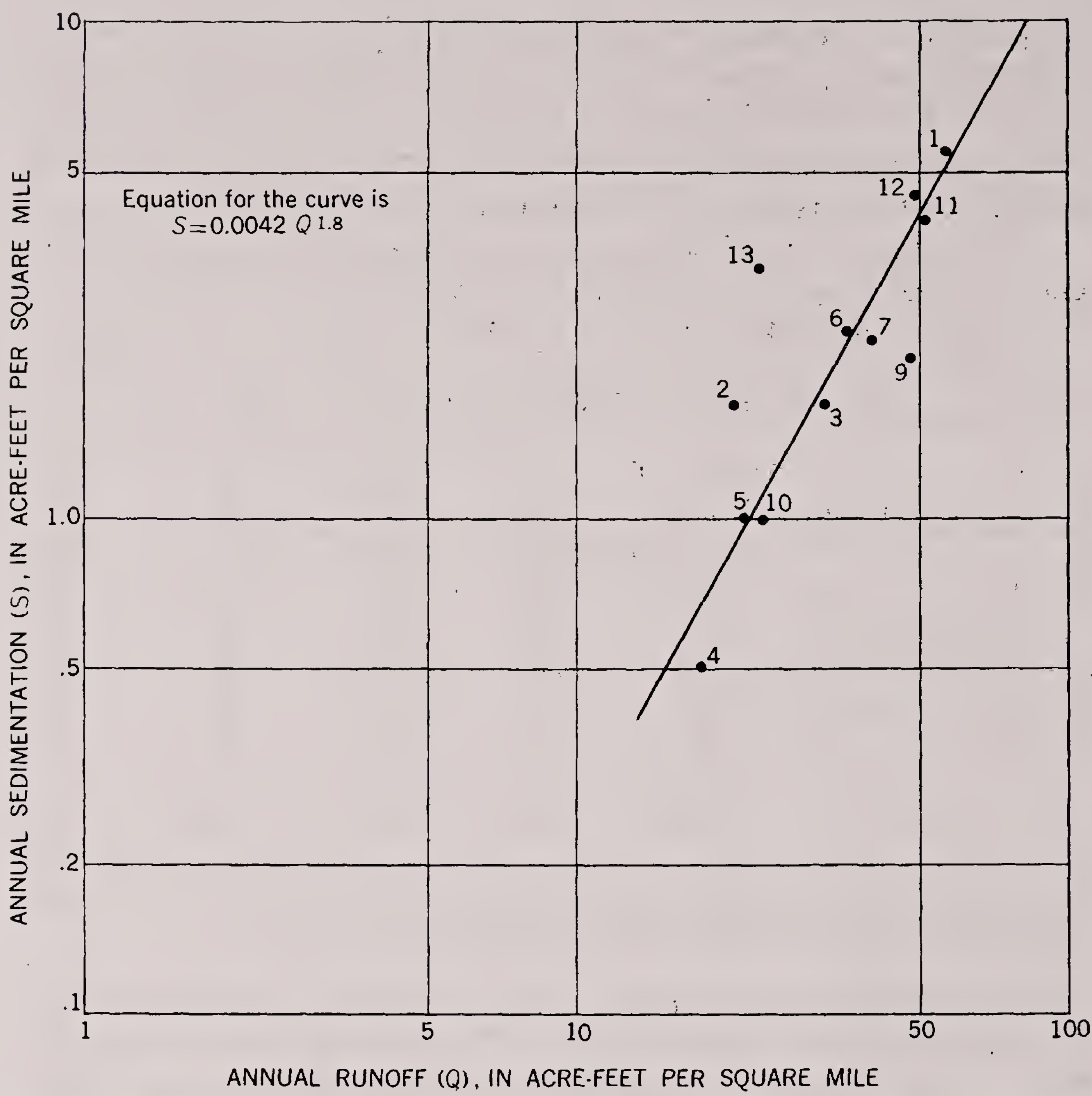

FIGURE 21.—Relation between sedimentation and runoff, 1951–55. Numbers indicate reservoirs at which sediment measurements were made.

The high ratio shown for reservoir 2 is somewhat anomalous, as this drainage basin is one of the least gullied ones. Sheet erosion must be relatively greater here than on other comparatively non-gullied areas, such as the basins above reservoirs 4 and 10.

The relation between sediment yield and runoff, both expressed as acre-feet per square mile of drainage area, is shown graphically in Figure 21. The relationship is fair, and the curve shown suggests that the sediment volume approximates a power function of the runoff volume. The equation for the curve shown is $S=0.0042\ Q^{1.8}$, in which S=sediment, in acre-feet per square mile per year, and Q= runoff, in acre-feet per square mile per year.

It was thought that a relation might exist between the ratio of sediment volume to runoff volume and the drainage area (in square miles), but the plot showed such scatter that obviously the relationship is at best very vague, with reservoir 12 being completely anomalous. These data are too limited to prove or disprove that a con-

sistent relation exists between size of drainage area, the volume of runoff, and the amount of sediment yielded by the drainage area.

In summary, the data show that in the 5-year period reservoirs 1 to 17 stored a total of 321.0 acre-feet of sediment from a drainage area of 22.90 square miles. This represents an average annual accretion of 2.80 acre-feet of sediment per square mile of drainage area. The aggregate capacity of the 15 reservoirs was reduced from 791.3 acre-feet in 1951 to 485.0 acre-feet in 1955, a loss of 39 percent.

EVALUATION OF BENEFITS

Considering the original objectives of the treatment program of the Bureau of Land Management, the performance of the reservoirs to date has been hydrologically successful. Formerly destructive floodflows from the drainage area have been reduced to amounts discharging through the 24-inch outlet pipes in reservoirs 11 and 12 and the 12-inch outlet pipe in reservoir 1, plus the relatively small amount of spill from reservoir 12 that occurred in 1954 and 1955 and the spill from reservoir 1 in 1955 (see table 7). Reservoir 11 has not spilled. This reduction of floodflows has largely eliminated flood damage to the Indian farmlands below reservoir 12 and has checked the advance of the major channel headcut located just downstream from the Indian farms.

A measure of the benefits may be visualized by reference to the storm of July 31, 1951. It is estimated that without the reservoirs, this storm would have produced a peak flow of between 6,000 and 8,000 cfs. Such a flow would doubtless have been sufficient to damage seriously, if not destroy, the Indian farmland. In contrast, the maximum flow from the outlet pipes in reservoirs 1, 11, and 12 during this period was about 80 cfs. The reservoir discharge lasted for several days, with a large part being used for irrigation.

Formerly, uncontrolled floods of this size would inundate the Indian farmlands and severely damage or destroy the crops. In addition, the floods caused rapid advancement of the gully headcut. Once the headcut advanced above the farmland, the lands had to be abandoned because the Indians could no longer use smaller floodflows for irrigation, which was essential to the success of their farming operations. The recurrence of uncontrolled floods accounts for the moving of the Indian farms several miles upstream along Cornfield Wash during the past 40 to 50 years.

The storm of July 31, 1951, produced a total measured runoff of 580 acre-feet. The storage capacity of 726 acre-feet then available in reservoirs 1 to 13 was ample to contain this flood, but should a storm of similar magnitude occur at present, with the aggregate storage capacity reduced to 485 acre-feet, the spill would amount to

95 acre-feet, assuming that the runoff was distributed so as to fill all reservoirs. Thus, so far as flood control is concerned, the reservoirs have been significantly reduced in their effectiveness in 5 years. The principal control reservoir, No. 12, spilled in 1954 and again in 1955. It has a present (1955) capacity of only 23.4 acre-feet per square mile of drainage area (see table 2) as compared to an original capacity of 43.5; and with reservoirs 3, 4, 5, 6, 7, 10, and 13 reduced to very small capacities, less regulation of floodflows in the future is in prospect.

There is no way of determining from available data if runoff during the 5 years of study was above or below normal. As noted previously (table 5), precipitation during this period was slightly higher in Cornfield Wash than at other nearby stations, but the records at 10 surrounding long-term U.S. Weather Bureau stations show that precipitation during the same 5 years was less than the long-term average at the stations by amounts that averaged 15 percent. From these records it might be concluded that runoff during the period was probably about normal, and that problems of flood control in the future would be similar to those experienced during the study period.

It is of some significance that 2 of the storms experienced during the period exceeded 1 inch of precipitation in 30 minutes. On the basis of the study made by the U.S. Soil Conservation Service (p. 61), both storms would be classed as events of 50-year frequency. Therefore, it is not impossible to experience 2 storms within a 5-year period that can be classed as "50-year" events. Only time will tell if the predicted expectancies are correct. But even without storms of such intensity, heavy runoff occurred in the 5-year period, and several floods would have resulted if the reservoir regulation had not been available. Should the sediment yield continue at the rate measured in the past 5 years, the effectiveness of the reservoirs will be essentially ended within another 5- to 10-year period.

The reservoirs have also been successful in providing a source of domestic, stock, and irrigation water for the Indian settlers. Only on rare occasions of short duration have all the reservoirs in the basin been dry simultaneously, and during a large part of the time most of them contained water. To the Indians, compelled to haul their domestic supplies by truck or team and wagon, a source of water close at hand is a valuable asset (see pl. 10*B*). The quality of water appears to be satisfactory, as the Indians fill their barrels for domestic use directly from the reservoirs. The advantage of having stock water distributed throughout the grazing area is obvious.

For irrigation, the amount stored in reservoirs 11 and 12 averaged 446 acre-feet annually during the 5-year period, with a minimum of 401 acre-feet in 1951 (see table 4). Except in 1951, when all the runoff resulted from the storm of July 31, the flow during other years was distributed so that irrigation water was available for use during several days in July, August, and early September. Since the water was available in amounts limited to that discharging through the two 24-inch pipes, it could be used for irrigation by the Indians. Although the irrigation was not as effective as it might have been with more experienced farmers, it nonetheless permitted the Indians to achieve substantial increases in their farm crops.

As with flood control, the value of the reservoirs as a source of domestic, stock, and irrigation water is being rapidly reduced through sedimentation. In constructing the dams, all the construction material was taken from rectangular pits located above the dams and excavated to a depth of 6 to 10 feet with 1:1 side slopes. As the excavation was below the level of the outlet pipes, the pits held water nearly all year in the early stages. The pits, being ideal for storage of sediment, filled rapidly, and all are now (1955) nearly full, except for the newer structures. Thus, the holdover storage available for domestic and stock use has, to a large extent, been reduced.

The high rates of runoff and sediment yield measured during the 5-year period is one of the surprising features disclosed by the study. The average seasonal runoff for the 22.90 square miles of drainage area studied during the 5-year period is 863 acre-feet or 37.7 acre-feet per square mile of drainage area. This exceeds by a large amount the runoff measured at most gaging stations located on ephemeral streams of the middle Rio Grande region, as shown in table 6.

The 5-year record, which is indicative of the storage requirements, is useful in the design of conservation structures, particularly where reservoirs are to be used for flood control. Of the 12 reservoirs with 5 years of record, only reservoir 2, with a storage-capacity ratio varying from 49.7 acre-feet per square mile of drainage area in 1951 to 41.7 in 1955 and reservoir 11, with a ratio ranging from 55.6 in 1951 to 35.7 in 1955, have not spilled. Reservoir 1, with an original storage-capacity ratio of 61.5 acre-feet, did not spill until 1955 when the ratio was reduced to 35 acre-feet. Thus, the 5-year record indicates that effective flood control requires a storage capacity of about 40 to 60 acre-feet per square mile of drainage area.

The record of sediment yield from the area during the 5-year period is likewise of great importance in the design of conservation structures. As with runoff, there is some uncertainty as to whether

this record represents a normal period; but assuming that it does, the average measured annual yield of 2.80 acre-feet of sediment per square mile of drainage area indicates that additional storage must be provided if reservoirs are to be effective for a reasonable period of years. Observations in the upper Rio Puerco area indicate that erosion and sediment yield in Cornfield Wash is fairly representative of conditions elsewhere in the basin. It is concluded, therefore, that in designing structures for flood control, the allocation for storage of sediment should be about 2.5 to 3.0 acre-feet per square mile of drainage area annually for the expected life of the structure.

In an effort to conserve the remaining storage capacity of the reservoirs, a cooperative study was begun in the spring of 1956 by the Bureau of Land Management and the Geological Survey on how to induce aggradation in the channels above the reservoirs. The plan is to erect a series of barriers that starts near the upper end of the reservoirs, where deposition begins, and extend upstream. The barriers are designed to reduce the stream velocity and force some spread of the flow beyond the channel, thus causing the stream to drop its sediment load. By building the barriers in stages as each successive one fills and by holding the sediment slope to a gradient that will not initiate additional cutting by desilted flow, it is possible that the channels can be filled and the valley floors restored to the condition existing before the recent gullying. A barrier located above reservoir 7 is shown in plate 11. By use of a simple hog-wire obstruction similar to the one shown, the channel above this reservoir has been filled for more than a quarter of a mile above the dam and several feet above the spillway level. It remains to be seen if the newly deposited fill will remain stable under more rigorous flow conditions in the future.

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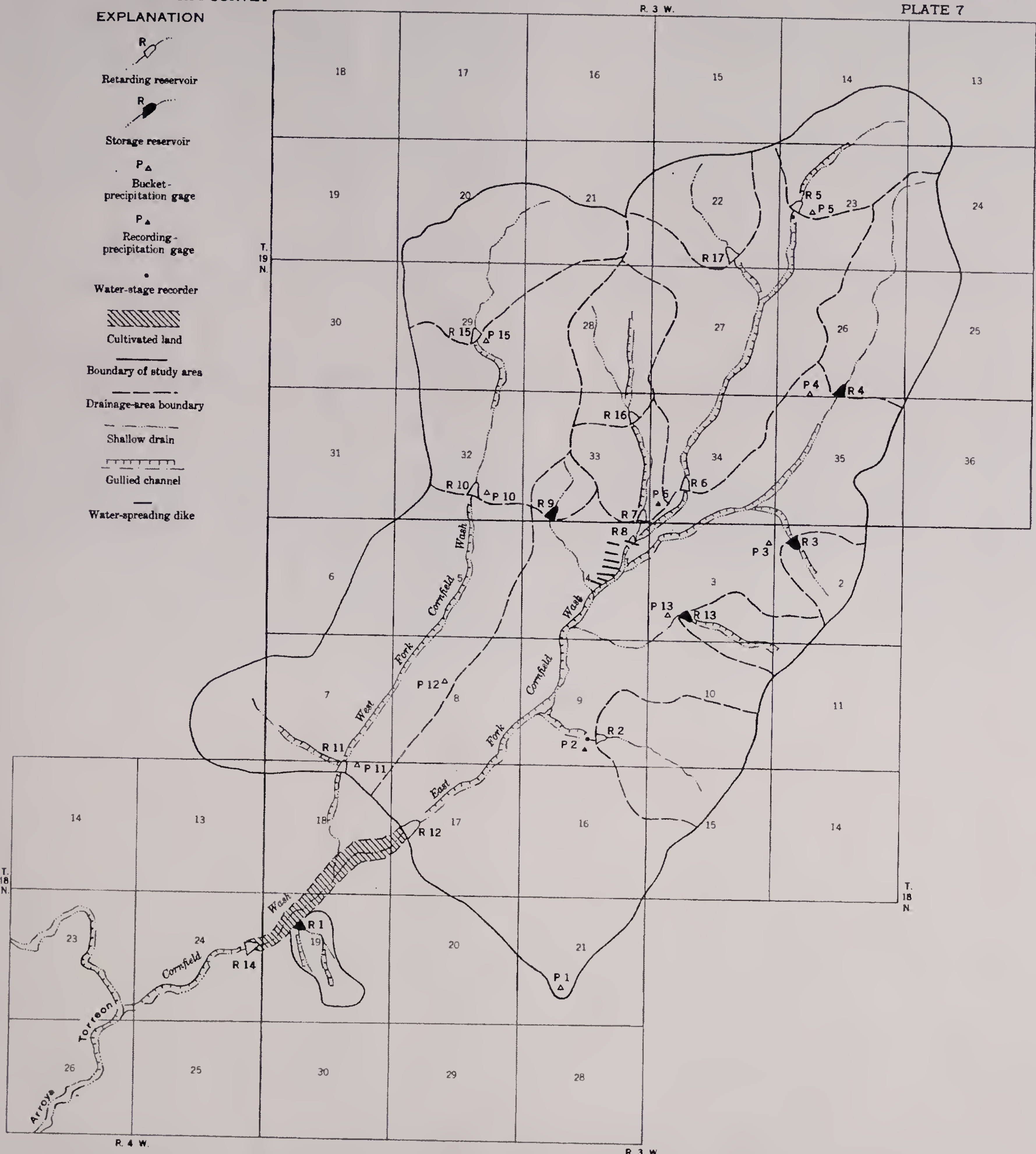
UNITED STATES DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

WATER-SUPPLY PAPER 1475
PLATE 7



MAP SHOWING LOCATION OF RESERVOIRS, PRECIPITATION GAGES
AND WATER-STAGE RECORDERS, CORNFIELD WASH
SANDOVAL COUNTY, NEW MEXICO

1 ½ 0 1 2 MILES